THE PEDAGOGICAL SEMINARY AND

JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior, and Comparative Psychology

EDITED BY

CARL MURCHISON

VOLUME XXXIX

1931

Published quarterly by the
CLARK UNIVERSITY PRESS
Worcester, Massachusetts
U. S A

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$7.00 per volume
Single numbers $2 00

QUARTERLY

March, 1931
Volume XXXIX, Number 1

Founded by G Stanley Hall in 1891

THE PEDAGOGICAL SEMINARY AND JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior, and Comparative Psychology

MARCH, 1931

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Worcester, Massachusetts

Entered as second-class matter August 3, 1897, at the post-office at Worcester, Mass, under Act of March 3, 1879

THE EQUIVALENCE OF STIMULI IN THE BEHAVIOR OF MONKEYS*[1]

From the Behavior Research Fund, Chicago

HEINRICH KLUVER

THE PROBLEM OF BASIC MECHANISMS IN BEHAVIOR

In viewing the responses of an animal to various stimuli, the question arises as to the basic functions involved in these responses. We are not satisfied with knowing that certain stimulus-response relationships exist. We want to know something about the mechanisms operative in determining the responses of an animal to its environment. It does not seem possible to arrive at such knowledge by determining stimulus-response relationships in a haphazard manner In such a way we may merely arrive at hundreds of disconnected behavior items, which, though "objectively" established, do not throw much light on the nature of the psychological, physiological, neural, etc., equipment of the animal To find that certain responses do occur is one thing, to find that these responses occur, and occur in a certain fashion, because of the animal's being equipped with certain mechanisms, is another thing In other words, trying to establish stimulus-response relationships is different from trying to understand such relationships in terms of the equipment of the animal. In the first case we want to know about the occurrence or non-occurrence of certain reactions under given conditions; in the second case we are interested in the mechanisms involved in these reactions. Simplifying the situation somewhat, the problem may be stated thus: We are not merely interested in determining that *n* responses occur *in the presence of n* different stimuli, but we want to obtain exact information about the sensory, emotional, etc., in short, psychological *mechanisms involved in* the behavior of animals while reacting to environmental stimuli In the present study we are chiefly concerned *with the mechanisms* operative in monkeys while reacting to sensory stimuli The problem may be stated differently. In case we do not

*Accepted for publication by K S Lashley of the Editorial Board and received in the Editorial Office, April 5, 1930

[1]Studies from the Behavior Research Fund, Chicago; Ernest W Burgess, Ph.D., Director Series B, No. 162

state it with reference to the reaction mechanisms of the organism but with reference to the stimuli reacted to, it may be formulated as follows: *Which aspects of the stimulus situation are primarily effective in, or are the chief determinants of, the behavior of the monkey?*

We have stated the problem in a very general way. The study of sensory mechanisms involved in monkey behavior necessarily reduces itself to the study of a large number of special questions. We do not consider these special problems at present.

Stimulus-Response Psychology as a Wrong Approach—What Are the "Responses"?

There is no doubt that in studying the problem formulated we must rely on reactions to experimentally controlled stimuli. But such a statement is as superficial as the statement that psychology should be stimulus-response psychology since the solution to our problem (as well as to other problems in psychology, to be sure) is not found by registering responses to stimuli, but by very definite ways of varying the stimuli systematically. The manner of variation is of paramount significance. Unfortunately, it is as impossible to lay down a general rule for the most effective procedure in varying stimuli as it is waste of time to assert that sticking to the stimulus-response formula would make a "science" out of psychology. The very aim of research is to find out what the responses of the animal are How, then, could we *begin* with responses? Let us consider a few examples.

Suppose we find that an animal is able to distinguish two circles differing with respect to one variable only, as, for instance, brightness, and let us assume that the stimulus situation is perfectly controlled Still we do not know whether the animal responds to the brightness-difference; and our suspicion that it does not finds some support when we discover that the same animal cannot distinguish two triangles of the same area, brightness-difference, etc , as the circles It follows that the response of the animal to the circles is not merely a response to a brightness-difference But what, then, is the "response" of the animal in this case? To be sure, if the stimulus situation is controlled, we know that the brightness-difference becomes somehow effective, but that is all we know Briefly stated: Our example shows that while physically we may have nothing but a brightness-difference,

behaviorally the response is inadequately characterized by considering it a response to a brightness-difference

Let us consider another example Suppose an animal after a long period of training reacts "positively" to one of two spectral bands differing in wave lengths only, let us say to 655 mμ instead of 505 mμ. What is here the "response" of the animal in case we find that the same animal being confronted with 595 mμ and 478 mμ reacts at once positively to 595 mμ in 100% of the cases?

A final example. *Let us assume that two different animals* are trained on stimuli involving nothing but a brightness-difference In 100% of the cases both animals respond to the brighter of the two objects by pressing a key Are we justified in maintaining that the "same" response is made by either animal? By confronting the same animals with a yellow and a blue object, we presently find that one of the animals chooses the yellow object in 100% of the trials, the other animal in about 50% of the trials. That means, we have every reason to assume, that the responses of the animals were "different" to begin with, although we must insist that physically the same brightness-difference was introduced for both of the animals. Only a layman would be inclined to call the pressing of a key the "response"; scientifically, it is, to say the least, misleading to speak here of a response In our case it is even wrong, since we know *enough about the effects of peripheral* stimulation in the visual field *to say that the response of the organism* as elicited by a difference in brightness is not identical with the raising of a leg to press a key

Whenever we obtain results similar to those given in our three examples we are at a loss concerning the "response" of the animal. It seems, therefore, that everybody interested in determining the actual responses of the animal as elicited by stimulation must dispose of the stimulus-response formula, since it is not only misleading and incorrect but positively harmful, inasmuch as it keeps us from finding out what the responses of the animal are

What Are the "Stimuli"?

There appears to be nothing wrong with a stimulus-response psychology when it comes to insisting upon a perfect control of the stimuli used. But the picture of exactness fades when we find that even in quantitative work it is not always possible, as H. M. Johnson (1) has pointed out, to control two variables at the same time. It is, for instance, impossible to control area and brightness simul-

taneously. (Some evidence might be brought forward to support the far more radical statement that it is never possible to equate two stimuli in all respects except one. But we shall not argue this point at present.) At any rate, in quantitative as well as in qualitative work, our attempt at keeping all variables except one constant results very often in a failure. Of course, the behaviorist will advocate ways and means of dealing with such a situation. We shall not consider the procedures he may use for remedying it. We propose to show that the control of the stimulus situation raises problems which represent almost unsurmountable difficulties.

Let us consider the ideal case in which all variables except one are controlled. What does that mean physically? *It means that the stimuli are identical in n—1 characteristics and that they are different with respect to one characteristic.* The fact that all differentiating characteristics except one are *absent* implies that *n—1* identical characteristics are *present.* We believe that the importance of this fact for the study of animal behavior has never been brought out clearly. This fact throws light on many hitherto unexplained experimental findings. We indicate its signficance by raising two questions: (*a*) Why should the presence of *n—1*, let us say 10, characteristics be less important in determining the response of the animal than the presence of one distinguishing characteristic? As could be easily shown by a review of the literature, the assumption of the lesser importance of the identical characteristics cannot be made; (*b*) What has been done in determining the effect of each of the identical (in our example, 10) characteristics referred to? A review of the experimental literature available shows clearly that in this respect certainly not very much has been done in a *systematic* way.

So far we have stated a few of the difficulties encountered in any research on the basic mechanisms involved in animal behavior. It is our belief that a presentation of these difficulties is of considerable value. There is at least some advantage in knowing that the stimulus-response formula is practically worthless, since "stimuli" and "responses" in animal behavior work are highly obscure matters.

The Method of Equivalent Stimuli

We have stated the problem and the difficulties centered around this problem at some length. We shall proceed to describe shortly a method which, although it does not answer all objections we are able to raise, seems nevertheless to be a step in the right direction.

We call this method the "method of equivalent stimuli" We have used it in our work on Macaques (*Java monkeys*) *from 1925 on* It was used in our experimental work at the University of Minnesota, 1925-1926, and at the Behavior Research Fund, Chicago, from 1928 on. The method was developed *in starting from the well-known* transposition experiments of Lashley and Kohler. Reference was made to it in a paper entitled "Relational Thinking in Monkeys" (2) given at the meeting of the *American Psychological Association in* New York City, December, 1928, and in a paper entitled "The Equivalence of Stimuli in Monkeys" (3) given at the International *Congress of Psychology in* New Haven, September 2, 1929.

To repeat: We want to know something about the basic mechanisms in animal behavior by finding out which aspects of the stimulus *situation are primarily effective* The method used involves two steps: (*a*) A difference (or differences) between two stimuli presented either simultaneously or successively is (are) made effective *through training, that is to say, the animal is trained to react positively* to one and negatively to the other stimulus It is not essential to the method that the differential response is set up through a process *of training. There are differential* responses which on the basis of our present knowledge are not the effect of training. Nor is it essential that *two* stimulus objects are used. One stimulus object, for *instance, is sufficient* (cf. "pulling-to-stop" technique below); (*b*) In "critical" trials, to use Kohler's expression, we replace the training stimuli by stimuli differing in one or several characteristics from the ones used or by "totally different" stimuli. The animal, no matter what its reactions in the critical trials are, obtains food in all trials. Suppose we find now that it reacts in 100% of the critical trials positively to one and negatively to the other stimulus In case the consistency in the animal's responses is clearly the "after-effect" of the training situation—there are cases in which the consistency as found at this point has nothing to do with the differential response set up during training—we consider the critical stimuli as *equivalent* to the stimuli used in training (Of course, it is possible that instead of the 100% correct trials, a very high percentage of correct reactions or some other criterion has been used during training. The point is that in the critical trials we rely on the same criterion by means of which the validity of the differential response during training has been established.) In case we find that the animal responds in about 50% of the trials to one and in the remaining 50% to the other stimulus,

we consider the critical stimuli *non-equivalent*. We speak of non-equivalence, too, in case the animal, though responding consistently to one of the stimuli, does not react in terms of the training situation. By experimenting with a large number of different pairs of critical stimuli, we arrive finally at groups of equivalent and non-equivalent stimuli. We call the equivalence (and non-equivalence) arrived at in such a way *objective* equivalence.

Experimentally our method involves only two steps. *To arrive at an answer to the problem formulated we must concern ourselves with a further task* Indeed, *the next step, the third one, is the most important one as regards our problem* It consists in an analysis of groups of *equivalent and non-equivalent stimuli, i.e., in a search for those characteristics of the stimuli which account for the equivalence or non-equivalence as experimentally found. On the basis of* such an analysis, we are able, in case our groups of equivalent and *non-equivalent stimuli are sufficiently large, to characterize in a* preliminary way the functions involved in bringing about objective equivalence. In other words, the third step is the step from objective to *functional* equivalence. It means that the kind of consistency found in various differential responses of the animal—i.e., objective equivalence—is now understood by reference to some function operative in a variety of stimulus situations—i.e., by reference to functional equivalence The information concerning functional equivalence thus gained necessarily leads to further experimentation.

It is perhaps unnecessary to add, though it cannot be emphasized too much, that whatever our results concerning objective and functional equivalence are, they represent results in terms of certain experimental conditions and certain animals Furthermore, the critical stimuli are introduced at a certain point of the learning curve in case we have *trained* the animals with respect to a set of stimuli The introduction of critical stimuli is *always* preceded by a period in which consistency in the differential responses of the animal has been found. These facts have to be kept in mind when it comes to general statements about basic mechanisms in animal behavior since such generalizations are nothing but attempts to summarize very special findings.

The Method of Equivalent Stimuli in Its Bearing on Studies of Animal Learning

At this point an important question may be raised. Why, we may ask, resort to the method of equivalent stimuli if learning curves are

able to tell the whole story? Experimental studies show that certain reactions of the animal are easily learned while others are acquired with the greatest difficulty. Some reactions seem to require hardly any learning The question is pertinent Does not an analysis of the different types of learning curves give us the desired information about basic mechanisms involved in learning? It does if the study of learning is centered around the problem as to what it is in the psychological, physiological, and neural, etc, equipment of the animal that accounts for the type of learning observed To find out that parathyroidectomized rats fail to learn or are inferior to normal rats in learning a certain maze does not give us any information as to the nature of the mechanisms interfered with through the operation. The chief reason for this lack of information is that at present no clear-cut results as to the mechanisms involved in maze learning are available It is hard to imagine that such results will be forthcoming unless a frontal attack on the problem above formulated is made: Which properties of the stimulus situation are primarily effective in determining the behavior of the animal? The fact that a certain performance, e.g, a maze performance, is far more difficult than another performance of the same kind, as shown by time-and-error-curves, does not tell us anything about the functions involved. Such a fact does not constitute the slightest proof for the assumption that the mastery of the "more difficult" maze implies "more complex" or "higher" functions In case such a statement is made, it generally means one of three things (*a*) that the author is working with a popular, prescientific conception of "complexity"; (*b*) that he is merely redescribing his data, i e, translating the greater "difficulty," which may be assumed on the basis of the time-and-error-curves, into greater "complexity", (*c*) that he bases his conclusion on facts not presented in the learning curves We are not concerned here with an evaluation of learning studies, but with bringing out the point that the procedures followed in many studies of learning are not likely to increase rapidly our knowledge of the chief determinants of animal behavior

The Pulling-In Technique

We have used the method of equivalent stimuli in experimental work on different genera and species of monkeys and on preschool

children. It is, of course, necessary to devise special techniques in connection with this method. In dealing with our subjects, we have employed a pulling-in technique with various modifications. In the following we shall describe this technique briefly by referring to our experiments on Java monkeys. The technique employed makes use of the observation that a caged-in monkey will pull in a box and examine it if we attach a string to the box, placing the box at some distance from the experimental cage. In case small quantities of food, such as slices of a banana or an apple, are put into the box, some animals will pull in the box as often as one hundred times in order to obtain the food. In most of the training experiments in which a *differential response was set up in the fields of* visual, kinaesthetic-tactile, acoustic, etc., *Wahrnehmung,* two boxes were presented. In the experiments involving differences in size and shape in the visual field, the shapes used were cut from black, stiff cardboard and glued to the front sides of the boxes. Both boxes were placed at the same distance, 150 cm., from the front of the experimental cage. Strings were attached to the food boxes and placed within the reach of the animal. The animal pulling in the correct box obtained the food; in case the wrong box was pulled, no food was obtained. No other forms of punishment were used. It is very easy to train a monkey not to pull the correct box after having pulled in the wrong box. In every trial only one of the boxes was pulled in completely. Three points must be kept in mind: (*a*) The boxes are movable, (*b*) they are placed at considerable distance from the cage; (*c*) the stimuli are attached to the boxes. "Distractible" as monkeys are, the animal may sometimes, without even looking at the objects, pull the wrong box for 20 or 30 cm. *But then, suddenly attending to the stimuli,* the correct box is pulled in. We found this technique superior to techniques which necessitate locomotion of the animal itself towards the stimuli.

In the experiments dealing with brightness-differences, the front sides of the food boxes as visible to the animal consisted of Hering's gray papers or colored papers from the Milton Bradley Co.

In the experiments dealing with stimuli differing in weight, boxes of the same size and appearance were used. (On account of the differences in weight, there are, of course, differences in friction.) To get the correct box in this case necessitates a "comparison" of the

boxes; that is, in order to determine which one of the two boxes is, for instance, heavier, the monkey must pull both boxes either simultaneously or successively. The procedure used by the monkeys observed so far was to displace both boxes successively. Through these successive displacements, here referred to as "comparisons," the position of the boxes frequently changed only a few centimeters out of a possible 150 cm. The boxes were moved, for instance, only over a distance of 1 or 2 cm. After this initial comparison, during which the animal frequently held the string of one box in his right hand, and the string of the other box in his left hand, the monkey pulled in one of the boxes.

The animals used the same procedure in their reactions to acoustic stimuli. In this case the monkey, by pulling the string of the box, closed an electric contact and sounded a buzzer built into the food box. By pulling the string of the other box, a different buzzer was sounded. The kind of "comparing behavior" found in the reactions to stimuli differing in weight was also observed here. Sometimes the animal "compared" 10 or 12 times, that means it caused slight displacements of the boxes by successive pulls. In some instances the pulls were sufficient for closing the contact but not for moving the box. This initial comparison was followed by the pulling-in of one of the boxes.

In some experiments the front side of the food box consisted of a piece of opal glass behind which an electric lamp was built into the box. It was possible to insert, for instance, filters or occlusion screens with variously shaped holes between the lamp and the glass.

In the pulling-in technique described so far, we have referred to two boxes. It is clear that the steps outlined under the method of equivalent stimuli can be adhered to with two boxes as well as with three or four boxes, etc., or with one box. It seems worth while to describe the procedure used with one box.

The Pulling-to-Stop Technique

This modification of the pulling-in technique has some definite advantages. In using one box we can do away with at least some of the troublesome control experiments necessary whenever two stimuli differ in certain respects. In presenting one box the animal is trained either to pull in the box completely or to stop after it has been pulled

over a certain distance. In most of our "pulling-to-stop" experiments, the stimulus object was placed at 300 cm distance from the front of the experimental cage. After the animal had pulled the object for 150 cm., some change was introduced; the weight of the box was increased or decreased or the front side of the box assumed a different color or presented an intermittently illuminated area instead of a stationary light, etc. The animal was trained to stop after such a change had been introduced. In critical trials changes different from those employed during training were introduced. Trials in which the object was pulled in completely, i.e., trials in which no change was introduced, and "pulling-to-stop" trials followed each other in chance order.

Objective Equivalence

In the following we present some results obtained chiefly on Macaques (Java monkeys) by using the method of equivalent stimuli in connection with the pulling-in technique. It is not possible, in fact, it would require a special monograph, to give a detailed description of the various stimuli used and of the many variations introduced to determine whether or not a pair of critical stimuli must be considered as equivalent. It is not possible either to report in detail about the control experiments performed. Suppose a differential response to two different buzzer sounds has been set up, the buzzers being built into the boxes and reacted to by the monkeys as described above. In such a case control experiments must be performed to determine, for instance, whether or not the animal depends on cues resulting from possible differences in the optical appearance of the boxes, or on differences in vibrations transmitted through the strings, or on cues from the experimenter. In all critical trials the experimenter has been excluded. The results are based on more than 30,000 trials, about one-third of them being critical trials, and on work with 10 monkeys. As indicated above, equivalent stimuli have been determined in various sense fields. We present some of the results assuming that they demonstrate the value of the method advocated and believing that they are of some significance for formulating further problems in the field of animal behavior. A detailed account of the experiments will be published later.

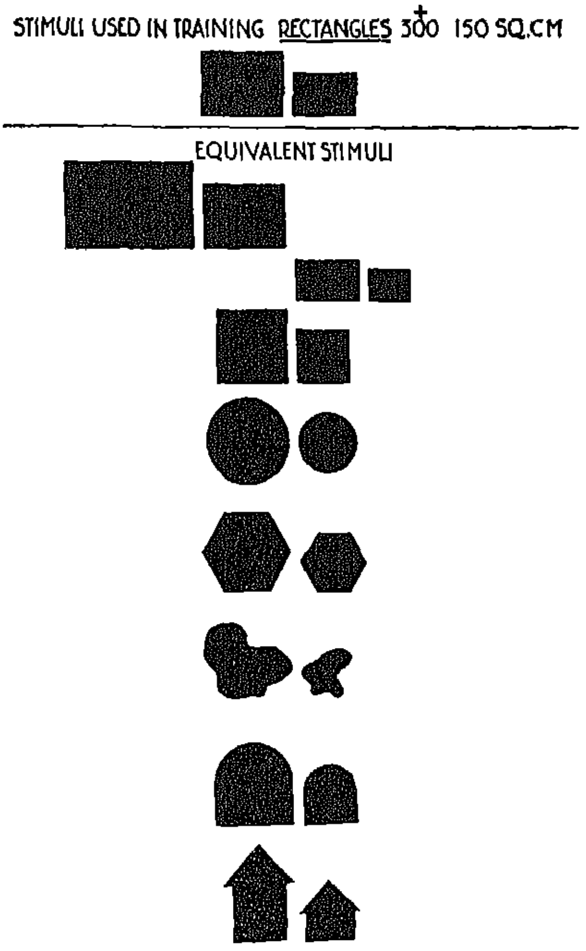

FIGURE 1

Figure 1. The stimuli used in training involved the "larger-than" relation The monkeys were trained to react positively to the *larger of two black rectangles.* The area of the larger one was 300 sq cm. (15x20 cm.), the area of the smaller one 150 sq. cm. (10x15 cm) Below these rectangles Figure 1 shows the pairs of critical stimuli found to be equivalent In reacting to these stimuli, the "larger-than" relation was effective in the same sense as during training

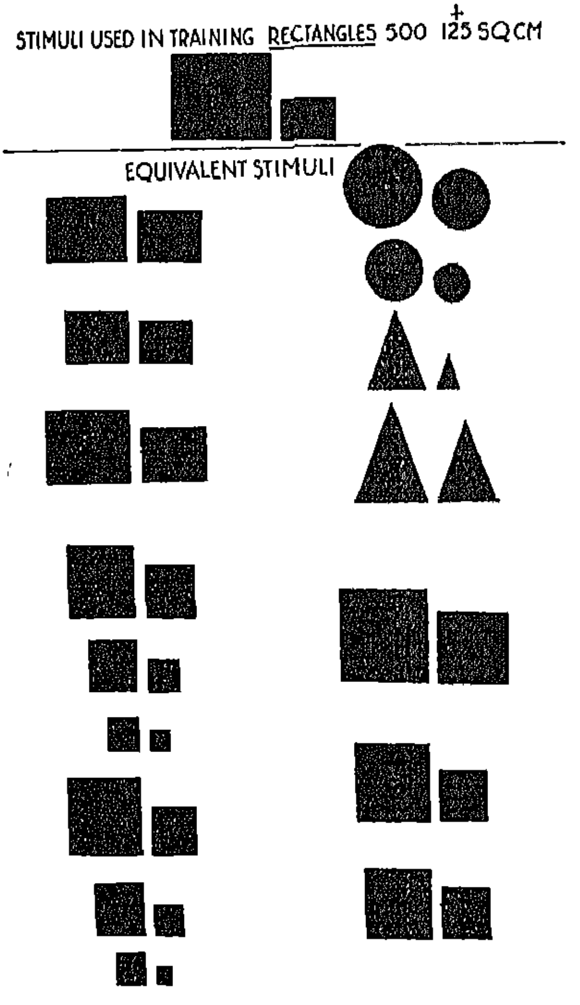

FIGURE 2

Figure 2 Here two other animals were trained to react positively to the smaller of two black rectangles, the areas being 125 sq. cm. and 500 sq. cm. Below this, the pairs of stimuli found to be equivalent are presented.

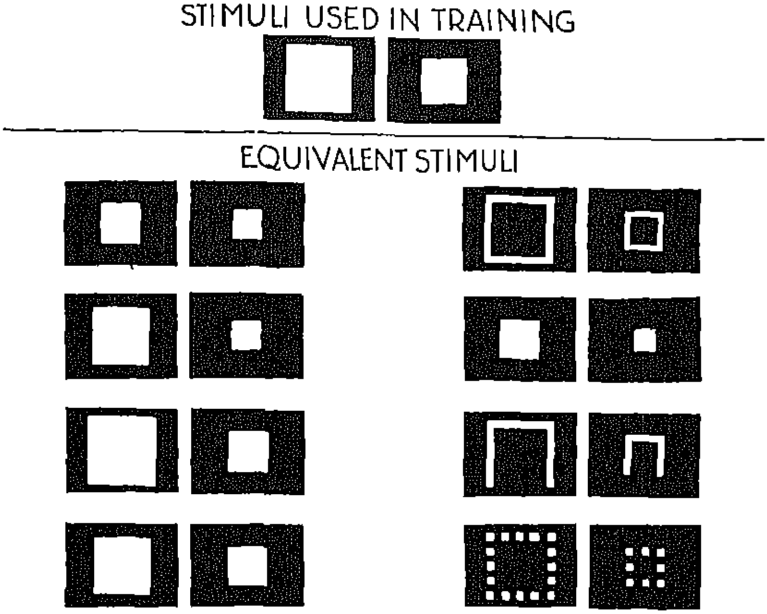

FIGURE 3

Figure 3. Here two figure-ground stimuli were used in training. The "figures" were squares which were painted on a black ground. The rectangular pieces of cardboard presenting the ground were of *equal size (15x20 cm.) while the squares differed in area.* The animals were trained on the smaller of the two squares. Inspecting the group of equivalent stimuli, we note that in critical trials even the contours of the square figure, when consisting of small squares, were sufficient to elicit the response to the smaller figure.

Figure 4. Here the front sides of the boxes consisted of opal glass surrounded by a black cardboard frame of 4 cm. width. The glass, as indicated above, was illuminated from behind by a 10-watt lamp in the box. In both boxes an occlusion screen with a 5-cm. square hole was *inserted* between the lamp and the box. The 5-cm. squares of the boxes as visible from the front differed in appearance since *the light in one box was stationary and in the other appeared intermittently* (on 2 sec., off 3 sec.). In training, the intermittent light was made effective. During most of the critical trials one box had a stationary light and the other an intermittent light. While in this

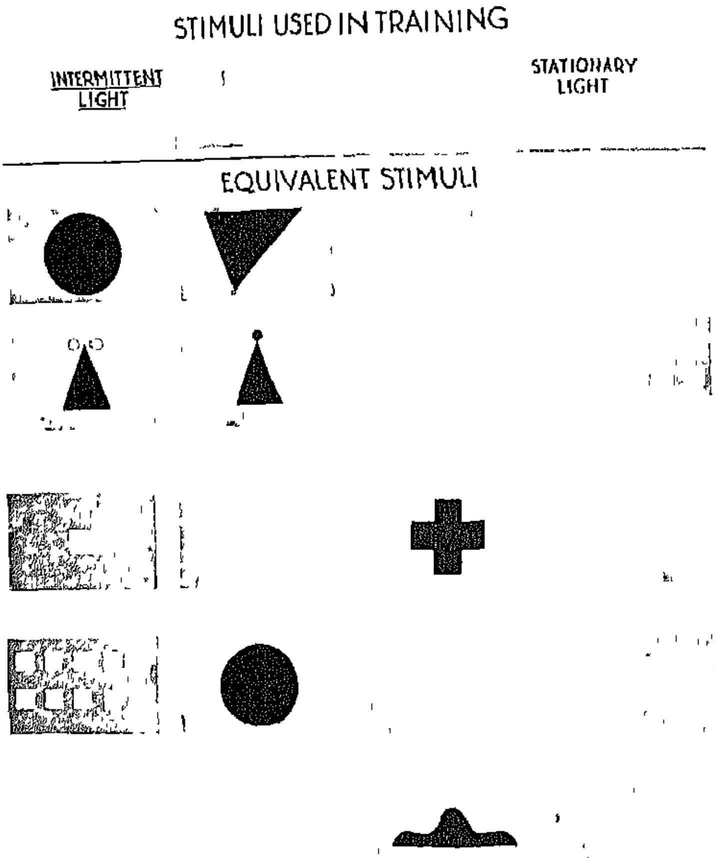

FIGURE 4

respect the conditions were the same as during training, they were different in many other respects. It will be necessary to describe these differences more in detail In the following, nine pairs of equivalent stimuli are described Figure 4 shows as the first critical pair a green circle and a red triangle The second pair consisted of a yellow triangle with red "corners" at the base and two small blue circles near the apex and a figure presenting a yellow triangular "body" with blue "legs" and a red "head" In the third pair, in both of the boxes, the total area of the opal glass with the exception of the square in the

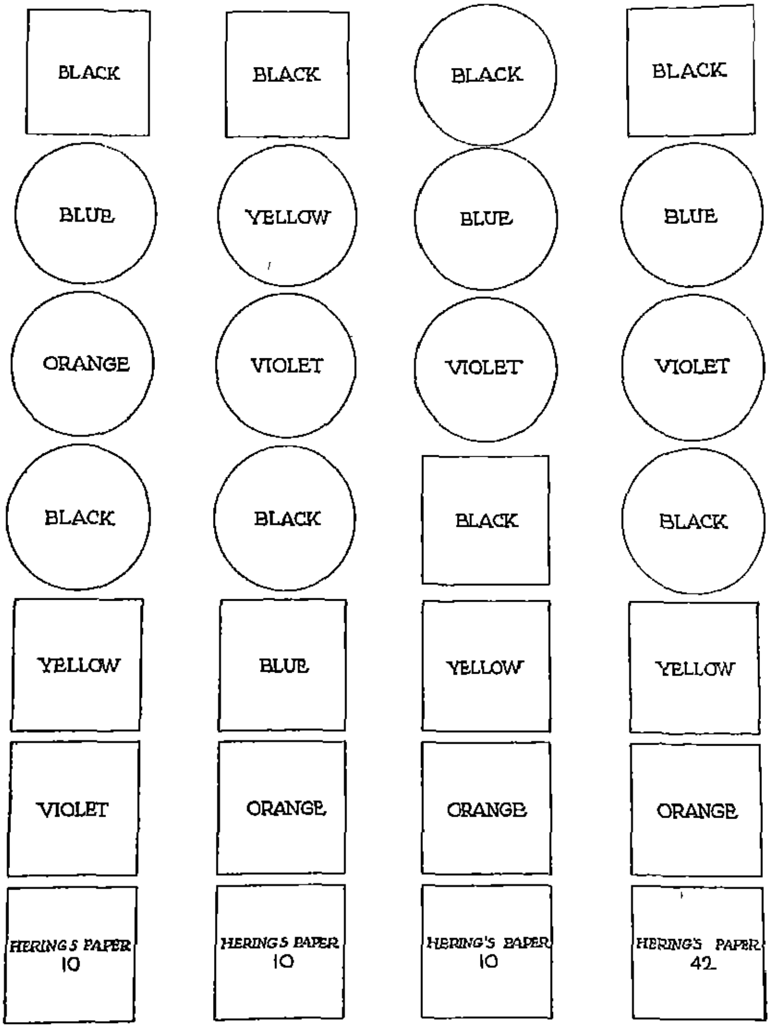

FIGURE 5

center was illuminated, but the *Umfeld* in one box was intermittent, while in the other, it was stationary In the fourth pair, the 10 squares of the one figure were intermittent, while in the other figure nine squares were stationary and only one, the middle square in the lower row, was intermittent. In the fifth pair, the size of the squares

as used during training was reduced from 5 cm. to 2.5 cm. The sixth pair shows the same pattern as used in the fourth pair and the green circle of the first pair. The seventh pair consisted of an orange cross and a white semicircle. In the eighth pair, one box was without illumination while the other showed the stationary 5-cm. square as used in training. The ninth pair consisted of an orange figure and an irregular pattern of white spots. As indicated above, one of the figures in these critical pairs was always intermittent and the other stationary. (This does not hold for the fourth and the eighth pair as becomes evident from our description.) Each figure, however, was intermittent in 50% of the trials and stationary in 50% of the trials, a chance order being worked out for presentation. In the reactions of the monkeys to the nine pairs of critical stimuli, the intermittent figure was positively reacted to no matter what its size, shape, color, etc. In the fourth pair, the positive reaction was to the 10 intermittent squares, in the eighth pair, to the box without light.

Figure 5. Here only two monkeys were used. Both of them had been trained on the larger of two rectangles (cf. the data presented in Figure 1). We intended to train one of the monkeys to react positively to a circle when a circle and three squares were presented as indicated in the first row of Figure 5. Very much to our surprise, no training was necessary. Without any training the monkey reacted at once to the circle, its area, 144 sq. cm. (and in some experiments its height) being the same as the size (or height) of the three squares. Of course, this reaction is not explainable by reference to the training on the larger of two rectangles. It was found in critical trials that the same monkey reacted at once positively to a yellow circle when confronted with one yellow and three blue circles (second row of Figure 5) and to an orange circle when one orange and three violet circles were presented (third row of Figure 5). This result was confirmed by the findings on the other monkey which, without any training, reacted at once to a square when exposed simultaneously with three circles (fourth row of Figure 5), and to a blue square when presented at the same time as three yellow squares (fifth row of Figure 5), and to a violet square when exposed simultaneously with three orange squares (sixth row of Figure 5), and to a square consisting of Hering's paper 42 when presented at the same time as three squares consisting of Hering's paper 10 (seventh row of Figure 5). Both monkeys had not been trained on brightness differences. It must be concluded that the sets of stimuli as shown on Figure 5 are equivalent.

TABLE 1

SHOWING REACTIONS TO STIMULI INVOLVING BRIGHTNESS DIFFERENCES
Stimuli Used in Training Hering's Papers

	+ 25 7 Equivalent Stimuli	
42 25		
		7 2
	25 15	
	15. 7	
	10 7	
	30 .15	
	Blue Yellow	

Table 1. Here the "darker-than" relation was made effective through training Numbers 25 and 7 of Hering's papers were used. The areas of the front sides of the boxes were 11 5 by 6 5 cm After the training on the darker paper, Number 25, had been completed the papers were replaced by other pairs The table indicates the equivalent pairs by giving the numbers of the papers used The animals responded positively to the darker papers in the different critical pairs and to blue instead of yellow, the colored papers being the "blue" and "yellow" of the Milton Bradley Co.

TABLE 2

SHOWING REACTIONS TO STIMULI DIFFERING IN WEIGHT
Stimuli Used in Training Weights

+ 450g 150g. Equivalent Stimuli			+ 465g 155g Equivalent Stimuli		
1350 450			1126 465		
900 450			801 465		
		150 50	761 520		
		150 90	864 625		
	300 150				155 60
	400 200		761	437	
	600·300				
	500	100			

Table 2 Here some animals were trained on the heavier of two boxes The 450-g box instead of the 150-g box was pulled in The boxes were gliding on a surface of cardboard. It is worth noting that at the end of the training period the animals did not "compare" the two boxes any longer in case the 450-g box, the correct box, was chanced upon first ("absolute" feel) In view of this fact, it seems

remarkable that in the critical trials always the heavier of the two boxes was chosen. In Table 2, the weights of the boxes are given in grams. Similar results were obtained on animals trained positively on 465 g. as compared with 165 g. Again, in critical trials, the heavier-than relation was effective in the same sense as during training.

In the auditory experiments, the animals were trained on the louder of two buzzers. These two buzzers did not only differ in loudness, to be sure, but also in other respects. In the critical trials, vibrator horns, doorbells, and the "positive" buzzer of the training experiments, along with a still louder buzzer, were used. These three pairs of stimuli were found to be equivalent to the pair of buzzers employed in training, the monkeys generally reacting to the louder sound in each pair.

The results so far presented concern objective equivalence. From an inspection of our figures and tables, it may now seem easy to single out those aspects of the stimulus situation which have been effective in determining the responses of the animal. But this cannot be done without considering the non-equivalent stimuli as found in our experiments. Referring to Figure 1, the conclusion seems justified that the animal being confronted with rectangles of the same relative size as used during training will always respond to the larger rectangle. On the basis of the data given in Table 1, we may expect the animal always to react to the darker of two papers in case the brightness-relation is the same as between Hering's papers 25 and 7. This conclusion, however, is not justified.

Finding that an animal always reacts to the larger of two black rectangles does not tell us whether the animal reacts to the *larger* or the *higher* of two rectangles, or to the larger of two *black* rectangles, or to the larger of two black *rectangles*, etc. In other words, we may find that the size relation does not become effective after changes in color, or shape, or even in absolute size, have been introduced. We must not forget that determining groups of equivalent and non-equivalent stimuli means nothing but separating conditions under which a larger-than or brighter-than or heavier-than or louder-than relation, etc., becomes effective, from conditions in which such relations do not become effective. Thus, our figures and tables merely indicate the special conditions under which objective equivalence has been observed; however, analyzed in a certain way and considered

in connection with findings on non-equivalent stimuli, they are apt to throw some light on functional equivalence.

Non-Equivalent Stimuli

Let us consider some of the results concerning non-equivalent stimuli. We present only a part of the results in order to illustrate how such data may be utilized for throwing light on functional equivalence. We shall consider a part of the results obtained with respect to size-differences in the visual field.

Animals, after reacting to the smaller of two white squares—the front sides of the boxes differing in size—were tested with respect to squares of the same color, size-difference, etc. But these squares, instead of constituting the front sides of the boxes, were figures as shown in Figure 3. It was found that the animals had to be retrained. The squares of the figure-ground stimuli were not equivalent to squares with the same characteristics representing the front sides of food boxes. However, after the animals had been trained on these square figures, a number of figures as shown in Figure 3 were found to be equivalent. Again, replacing the square figures by holes of the same size behind which at a certain distance a white screen was placed (Katz' *Reduktionsschirm*) seemed to represent a new situation, as judged by the fact that the animals had to be trained on these new stimuli. After the training, the size of the holes could be changed within certain limits without upsetting the response to the objectively smaller hole. Again, the same squares being patches of a certain brightness produced by illuminating the rectangular, black, front sides of the boxes did not call forth a response to the smaller of the two patches. After such a response had been established, it was not abolished by changing the color and size of the illuminated areas.

We find, then, that squares as *objects* (front sides of the boxes) are not equivalent to the same squares as *figure-ground* stimuli or to the same squares as *holes* in an occlusion screen (the front sides of the boxes) or to the same squares as *illuminated areas* on the front sides of the boxes.

We also know, considering for instance the first of the cases referred to—squares as "objects"—that introducing certain changes in absolute and relative size and color, etc., means abolishing the response to the smaller-than relation. (No data, however, are included to illustrate this point.)

Briefly stated: Training an animal on the smaller of two boxes means, as the experiments show, to incapacitate the animal for a large number of smaller-than situations and, at the same time, to enable it to respond to other smaller-than situations without any training. Expressed differently: There are certain critical stimuli, the non-equivalent stimuli, the characteristics of which make it impossible for the animal to react to them in terms of the stimuli reacted to during training; there are others, the equivalent stimuli, the characteristics of which enable the animal to respond to them in terms of the training situation. The very fact of training implies, of course, that certain aspects of the stimulus situation are effective or can be made effective, otherwise training would not be possible. But we do not know which of these aspects are effective This information is secured in the critical trials We find that in the *critical* trials the animal is able to fall back on mechanisms by means of which the characteristics, let us say, *a, b, d,* and *f* can be made ineffective in determining the response, while *c, e, g,* and *h* cannot

The material presented in our figures and tables, then, proves the existence of such mechanisms It does not tell us about the nature of these mechanisms, nor how "natural" it is for the animal to fall back on such mechanisms. But the following assumption may be made: If we find that only a very short training process is necessary for setting up a differential response and, then, find a large number of different stimulus conditions reacted to by the animal in terms of the training situation, it is very likely that we are dealing with the workings of a basic-mechanism

Functional Equivalence

On the basis of an analysis of groups of equivalent and non-equivalent stimuli in various sense fields, we shall in a very general way consider the equipment a Macaque relies on in its reactions to external stimuli or, expressed differently, those aspects of the stimulus situation which are primarily effective in determining behavior.

We find that in various sense fields *relations* between the stimuli must be considered primarily effective in determining the response of the monkey. Changing some of the properties of the stimuli radically does not necessarily change the response. To illustrate: A monkey continues reacting to the heavier of two objects although live rats—seen and responded to by the animal—have been introduced as part of the weight. The relation subsisting between two buzzer

sounds is still effective in the monkey's reactions to automatic vibrator horns as used in Ford cars. Certain differences in the visual field based, e. g., on the relation between different brightnesses are effective even in the presence of stimuli which do not involve differences in brightness but in shape. The relation involved in the change from a stationary to an intermittent light is effective even in the change from a stationary to a blue or red light.

We have stressed the importance of relations as determinants of *monkey behavior but have not characterized them in terms of psycho*logical functions. It is obviously not possible to express these relations in objective terms, though it is possible to describe them by reference to objective material. Having recognized the impossibility of describing relations "objectively" does not help us in attempting to characterize them "psychologically." In the following example we shall be content with showing the inadequacy of defining mechanisms "objectively."

Let us consider the larger-than relation. "Larger-than" is a relation between objective stimuli and does not imply anything functional. The "larger-than" relation on the objective side is not paralleled by a "responding-to-the-larger-one" mechanism on the functional side, since the mechanism involved in responses to the larger-than relation is, as experiments show, also operative in situations in which the animal, after previously having always responded to the larger object, suddenly responds to the smaller of two stimuli. To speak here of an "optical illusion" does not explain anything; in fact, it is not even a clear statement of the *problem*. We are not justified in introducing at this point a new mechanism, but must assume that the same mechanism operative in the reactions to the larger object is also functioning in the responses to the smaller object. We are justified in making this assumption on account of the consistency in the animal's responses. Not to commit ourselves, the psychological mechanism operative in the responses to the larger as well as to the smaller of two stimuli may be called *a*.

Dealing with monkeys, however, it seems far more promising to characterize this mechanism not as *a*, but in terms of a phenomenological analysis. We may find, for instance, that the different *stimulus configurations, the configuration in which the reactions to* the smaller object, and the configuration in which the responses to the larger object occurred in a consistent manner, involve phenomenally the "same" aspect for the experimenter. We do not emphasize

the necessity of such a subjective analysis but the impossibility of finding an "objective" general denominator for the stimulus situations in which consistency in the responses of the animal is observed, and the inadequacy inherent in the formulation of an *a* as a psychological function. Still the formulation of *a*-functions, etc., is a step beyond the findings on objective equivalence.

We have emphasized the importance the relational aspects in the stimulus situation have in determining the behavior of the monkey. At the same time, it would be quite wrong to assume that the animal, under the stress of certain objective relations is, as it were, mechanically *forced* to act in a given way. On the contrary, one gets the impression that a Macaque handles relations in an autochthonous manner. As has been shown recently, even a bee may respond relationally in case the stimulus material on which a given relation is based undergoes pronounced changes. To appreciate the relational reactions of monkeys, three points must be considered: (*a*) The changes introduced in our experiments during the critical trials are above the threshold; that the monkey is able to *distinguish* between the critical stimuli and the stimuli used during training is proved partly by control experiments and partly by the experimental literature available. (*b*) It is evident from the behavior of the monkey during the critical trials that the changes introduced are frequently *noticed,* that means that a monkey reacts relationally in spite of the fact that the differences between two sets of stimuli are well above the threshold or are attended to without any training. (*c*) The very fact that the animal works under controlled conditions obscures the "fragility" of relational reactions in monkeys. To illustrate: In case the experimenter is not excluded during the critical trials, we may find that the relational reactions are abandoned in favor of reactions to the "heels" of the experimenter. The experimenter, after having placed the stimuli before the cage, may walk away in a certain direction, for instance, to the left or to the right. This may determine the responses of the animal. The experimenter being excluded, it seems, indeed, the most "intelligent" thing to fall back on the stimuli and react to them in terms of the training situation. It is not contradictory to call relational mechanisms *basic* and *fragile* at the same time. The ease with which a basic mechanism may be thrown out of gear, in other words, its fragility, must be considered as important for the analysis of behavior as the existence of the mechanism itself.

The three points just discussed make it sufficiently clear that a monkey is not forced to act relationally under the stress of certain objective relations and that *the fragility of functions is as important a problem as their basic character*

At this point the fact must be recorded that in many instances the *absolute properties* of the stimuli, instead of the relations subsisting between them, are the chief determinants of the behavior of the monkey. In fact, the behavior of our subjects under various conditions is adequately pictured by assuming a continuum at the one end of which the relations between stimuli, and at the other end of which the properties of the stimuli are primarily effective In formulating experimental problems, some significance should be attached to the fact that the influence of "relations" combines in many ways with the influence of "absolute properties"

It becomes apparent from our discussion of functional equivalence that in this paper we have not endeavored to characterize in a concrete fashion the psychological mechanisms in the different sense fields investigated We have merely tried to bring out some general points concerning functional equivalence in Macaques when reacting to stimuli in the *Wahrnehmungsfeld*

In closing, some remarks on the advantages of the pulling-in technique may be added. By this technique it is easy to obtain data on equivalent stimuli in almost all sense fields as well as data on problems of sensory discrimination The technique is equally applicable to the study of affective responses and drives It may be used in the study of a number of special problems in the field of perception We have, for instance, collected some data on the problems of approximate constancy of color and size in the visual field, and on similar problems in other sense fields. It seems to be the method *par excellence* for the study of choice reactions We have been primarily interested in the processes of choice underlying reactions to stimuli differing in weight. It is possible, for instance, to measure exactly the time relations involved in the successive comparisons of the boxes and to determine the position of the boxes at various time points during the process of comparing The analysis of the kymograph records obtained in such a way is apt to throw light on problems of relational thinking

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Behavior Research Fund
Chicago, Illinois

L'EQUIVALENCE DES STIMULI DANS LE COMPORTEMENT DES SINGES

(Résumé)

1) On essaie de determiner expérimentalement quelques-uns des mécanismes fondamentaux qui se trouvent dans les réactions des singes (Macaques) aux stimuli dans les différents champs des sens.

2) On decrit la "méthode des stimuli équivalents." Le point départ est une résponse différentielle à une série de stimuli (Etape 1). Dans les épreuves "critiques" ces stimuli sont remplacés par des series de nouveaux stimuli. De telle façon, des groupes de stimuli sont déterminés lesquels, jugés par la résponse de l'animal, sont ou équivalents ou non-equivalents aux stimuli employés dans l'entraînement (Etape 2, l'equivalence *objective*). Jusqu'à ici, on peut considerer la méthode comme une modification de la méthode employée par Kohler dans son travail sur *Structur-funktionen*. On analyse les groupes des stimuli équivalents et non équivalents pour déterminer les caractéristiques des stimuli qui expliquent l'equivalence trouvee expérimentalement (Etape 3; l'équivalence *fonctionnelle*)

3) On considère les avantages de quelques-unes des techniques développées par l'auteur pendant les derniers ans récents pour ses experiences avec les singes

4) Les résultats, surtout ceux sur l'equivalence objective en tant qu'ils sont rapportés, montrent la valeur de la méthode recommandée et suggérent d'autres problèmes pour l'expérimentation Ces résultats sont basés sur l'expérimentation avec dix singes et sur plus de trente mille epreuves Dans les résultats ci-inclus il s'agit des effets de l'entraînement sur des stimuli différant en grandeur, en forme, ou en clarté (champ visuel), en poids ou en intensité. Dans quelques experiences on a rendu effective la différence entre une lumière immobile et une lumière montré par intervalles. Probablement pour la première fois, on a entraîne systématiquement les Macaques sur les differences dans le champ kinesthetique-tactile et le champ acoustique On présente des groupes de situations équivalentes de stimuli dans les différents champs des sens Leur analyse jette quelque lumiere sur la nature des fonctions a la base des réactions des Macaques aux stimuli sensoriels.

5) On appuie sur l'importance de la méthode pour les problèmes de la pensée "de relation"

Klüver

DIE AQUIVALENZ VON REIZEN IM VERHALTEN VON AFFEN

(Referat)

1) In der vorliegenden Untersuchung wird der Versuch gemacht, einige der Grundfunktionen, die in den Reaktionen niederer Affen (Macaques) auf Reize in verschiedenen Wahrnehmungsgebieten wirksam sind, experimentell zu bestimmen

2) *Es folgt eine Darstellung der in dieser Untersuchung benutzten* Methode der aquivalenten Reizkonstellationen" (*a*) Als Ausgangspunkt wahlt man eine Reizkonstellation, die eine Unterscheidungsreaktion des Tieres hervorbringt (*b*) In "kritischen" Versuchen ersetzt man diese Reizkonstellation systematisch durch eine Reihe anderer Reizkonstellationen Man kann dann aus den Reaktionen des Tieres ersehen, ob eine neue Reizkonstellation der Reizkonstellation, auf die das Tier wahrend der Dressur differentiell reagierte, aquivalent ist oder nicht objektive Aquivalenz In gewisser Hinsicht ist die Methode der aquivalenten Reizkonstellationen eine Modifikation der von Kohler in seiner Untersuchung uber Strukturfunktionen beim Schimpansen und beim Haushuhn beschriebenen Methode Im Gegensatz zu Kohler lassen sich freilich die in der vorliegenden Untersuchung benutzten Reizkonstellationen meistens nicht auf Reihen eines einzigen konstanten Verlaufsprinzips reduzieren (*c*) In einer Analyse der auf diese Weise festgestellten Gruppen aquivalenter und nichtaquivalenter Reize wird versucht, diejenigen Momente der Reizkonstellation herauszuanalysieren, die fur das Verhalten des Tieres dominierend sind und somit die experimentell ermittelte (objektive) Aquivalenz verstandlich machen (*funktionelle* Aquivalenz)

3) Einige spezielle Methoden, die der Verfasser fur seine experimentellen Untersuchungen mit niederen Affen ausgearbeitet hat und die sich im Laufe der letzten Jahre glanzend bewahrt haben, werden beschrieben

4) Es folgt die Darstellung einer ganzen Reihe objektiv aquivalenter Reizkonstellationen in verschiedenen Wahrnehmungsgebieten. Die mitgeteilten Resultate illustrieren nicht nur den Wert der Methode der äquivalenten Reizkonstellationen, sondern fuhren auch zu neuen experimentellen Fragestellungen In der vorliegenden Untersuchung wurden die Wahlreaktionen von 10 niederen Affen in mehr als 30000 Dressurwahlen und kritischen Wahlen festgestellt Die Affen wurden mit Erfolg auf Grossen- und Helligkeitsunterschiede sowie auf intermittierende Lichtreize (verglichen mit stationaren Reizen) dressiert Wohl zum ersten Mal wurden die Reaktionen von Macaques auf akustische und Gewichtsdifferenzen systematisch untersucht In einer Analyse der aquivalenten Reizkonstellationen werden die in dem Verhalten der Affen wirksamen Grundfunktionen psychologisch naher bestimmt

5) Verfasser weist auf die Bedeutung der von ihm erlangten Resultate fur das Problem des Relationsdenkens hin

KLUVER

THE RELATIVE EFFICIENCY OF DISTRIBUTED AND MASSED PRACTICE IN MAZE LEARNING BY YOUNG AND ADULT ALBINO RATS*[1]

From the Psychological Laboratories of Stanford University

BARBARA ANNE MAYER AND CALVIN P. STONE

The relative merits of various temporal intervals have been assessed in experiments on the distribution of practice in animal learning. As Cook (2) has aptly pointed out, however, "one finds several complicating factors that make it impossible to say with anything like positive assurance what particular temporal array of practice is preferable even in a given type of problem. Such factors as age, the type of subjects used, difficulty of the problem, primary or terminal massing, length of interval between successive periods of the training series, the number of records on which one may fairly base general conclusions, and the criteria of learning employed have an important bearing on the main problem." Having arrived independently at opinions similar to those of Cook, we formulated the present experiment for the specific purpose of determining whether age of subjects might have a deciding influence on the general results derived from spaced and massed practice. The very fact that young rats are more easily motivated to perform on mazes according to their full knowledge of the pathway than are well nourished adults is the basis for a working hypothesis that differences heretofore reported on the temporal influence of practice may be causally related to differences in motivation afforded by the experimental situations of massed and distributed trials.

In this report we shall be concerned with data amassed by giving different young and adult groups of rats 1, 3, 5, and 10 trials per

*Received in the Editorial Office, May 8, 1930

[1]A part of the expense incurred in this experiment was met from a financial grant by the Carnegie Corporation, contributed for a study of the age factor in learning (Stone 6, 7). We gratefully acknowledge the invaluable aid of two Research Assistants, Mildred Burlingame and Theodore C. Ruch, who trained animal groups *a*, *A*, *b*, *B*. Each of these assistants, by virtue of much experience with the instruments and technique described in this paper, was thoroughly competent to preserve the essential elements of experimental method prescribed and followed by the authors. The experimental data were gathered during 1927-1928

day on a multiple-T maze of 12 choices until each individual has run a total of 30 trials.

Animals

The albino rats were reared in the psychological laboratory of Stanford University, and prior to the inception of this experiment had been maintained in a state of high nutrition Table 1 gives the group designations, number of each sex, and the ages when maze training was given. To aid the reader in recalling the groups, we have used small letters to designate the young and capital letters to designate the adults Since sex differences have not been demonstrable in our laboratory in very young animals or in adults subjected to rigorous training conditions, we did not attempt to secure absolute numerical equality of the males and females. Ages of the younger groups varied from 26 to 30 days at the outset of their maze experiments. Ages of the adult groups are different, as indicated in Table 1, but all fall within that range wherein little if any account of the age factor in learning must be taken (Stone 6, 7).

Technique

1. *Maze.* The multiple-T maze employed in this experiment

TABLE 1

Animal Groups Tabulated as to Distribution of Practice, Sex, and Ages While on the Maze Experiment

Group	Trials per day	No of animals M	F	T	Ages while on maze
a	1	22	25	47	31-60
A	1	8	9	17	456-485
b	3	26	14	40	25-34 (N=11) 30-39 (N=29)
B	3	14	19	34	297-306
c	5	14	15	29	26-31
C	5	16	7	23	220-225
d	10	15	16	31	26-28

has been described as to form and reliability of scores by Stone and Nyswander (8) Following the practice stated in that earlier paper, we washed the floor of the maze daily while experiments were in progress in order to minimize the accumulation of differential odors along the true pathway and blind alleys There remains, however, the possibility of odors accumulating on the walls of the maze, but whether they serve as differential cues for the guidance of the rat is not known However this may be, if they really serve the rat in

maze learning, it seems probable that all groups, irrespective of distribution of practice, were given ample opportunity for their use.

2 *Preliminary Training.* When young as well as adult rats have had little or no handling prior to a maze experiment they may become so startled from time to time by minor sounds or movements of the experimenter that they remain motionless for as much as five or ten minutes before continuing toward the goal. To obviate this handicap, young Groups *a* and *b* and adult Groups *A*, *B*, and *C* were given preliminary training of five trials, one per day, on a simple platform box (Stone, 6, 7). The very young Groups *c* and *d* were not given this preliminary training on the platform box. Their conditioning consisted of daily handling by the experimenter, transference from cage to cage in the maze room, and of a few minutes feeding in the goal box on each of the five days prior to the beginning of maze training. To the experimenters it seemed that this handling of the very young might be roughly equivalent in value to that of five trials on the platform box and somewhat better suited to the animals of 21 days, since some of them are quite inactive for a trial or two when placed in problem boxes, and thus are unsuited to that type of conditioning for maze experiments. Evidence that Groups *c* and *d* suffered no particular handicap is given by their initial trials on the maze.

3. *Weight Reduction as an Aid to Control of Motivation.* The young animals of Groups *a* and *b* were given their preliminary training on the problem box without weight reduction beyond that incurred by a 24-hour fast. Their rate of gain while on the maze was approximately 1½ grams daily except during the first three or four days, when the gain was about 1 gram per day. Young Groups *c* and *d* began their maze trials after a 24-hour fast and gained approximately 1 gram per day during their short periods of training.

The adult groups were subjected to a more rigorous régime of fasting before their initial training on the maze in order that the greatest possible degree of responsiveness to food motivation while in training might be obtained. During the two weeks preceding their preliminary training these animals were reduced in weight by approximately 20% to 30% of their normal colony weight (e.g., an adult male weighing 350 grams or a female weighing 180 grams was reduced to approximately 280 or 144 grams, respectively). While on the maze their weights declined at the rate of ¼ to 1 gram daily. Our records show that the total loss for the 3- and 5-trial groups

was slightly less than that of the 1-trial group, but that their daily deprivation was no less severe during the relatively short time they were in training. Under this condition of weight reduction and control it has been found that adult animals are very alert and persistent in problem solving even on the initial trials. They, like the young growing animals, are highly motivated from the beginning to the end of a maze experiment

4 *Intervals Between Individual and Daily Groups of Trials* Animals receiving more than one trial daily were allowed an interval of 20 minutes between trials Preliminary tests of this method led us to believe that it minimizes chance scores arising from temperamental factors and the occasional exploratory tendencies cropping out in animals required to complete several trials in close succession. By running groups of 4 to 8 animals in rotation the experimenter's time was conserved

Those who would compare our results with results of other experimenters on this general problem should observe that the introduction of a standard interval of 20 minutes between trials entails a noteworthy variation (*a*) in the total span of time between the first and last trial of each day's quota and (*b*) between the last of one and the first of the next day's trials To be specific, an animal of the 3-trial group required slightly more than 1 hour from the beginning of the first to the end of the third trial, the 5-trial animals required about 4 hours on the first day and 2 hours daily thereafter, and the 10-trial animals completed their first day's quota in 7 hours and the second and third day's quota in 3½ hours All groups were given their initial daily trial between the hours of 8 and 9 A M Accordingly, there was a variable length of interval between the last trial of one day and the first trial of the next For the group receiving 1 trial per day this interval was 24 hours; for the 3-trialers, it was approximately 23 hours, for the 5-trialers, approximately 20 hours from the first to the second day and 22 hours thereafter; for the 10-trialers, it was 17 hours after the first day and 21½ hours after the second A rigid experimental program should not embody variables of the foregoing nature in an experiment of this kind. Yet, from a practical point of view, *they or others entailed by their elimination* appear to be inherent elements of the experiment itself To illustrate, attention is directed to the fact that by increasing the number of trials per day, one inevitably increases the temporal span between the first and last trial of any day's quota, he also places the break between last and

first trial of successive days at different points of the learning series, and, finally, unless he introduces a variation in the interval between last and first trials, the hour of the day at which one gives the first trial is progressively shifted forward. Although shifting the hour at which the initial daily trial comes eliminates the variable temporal interval between initial daily trials, this very correction introduces the new variable of running different groups at different hours of the day.

It is the authors' belief that the aforementioned technical variations are of little potency in determining learning scores of highly motivated animals and, moreover, cannot be detected statistically in groups of 20 to 30 individuals. Yet it must be emphatically stated that this is only an opinion and not an experimentally attested fact. Hence, in comparing the findings in this study with those of previous workers, one must not overlook the variations in conditions to which we have called attention.

5. *Measures of Learning.* Comparison of group performances have been made on the following bases.

a. Errors committed. Two types of errors were recorded. Errors of the first order (E_1) were listed if an animal entered a blind alley with two-thirds or more of its body while moving from entrance to goal. Errors of the second order (E_2) consisted of retracings on the true path or entrance into blind alleys while an animal was returning to the starting box. But one error was recorded for a continuous retracing on the true pathway, irrespective of the number of units traversed.

b. Trials to learn. Two criteria of mastery have been used. The first, very lenient, consists of the number of trials required to make three consecutive runs with a total of 3 or less errors. The second, moderately severe, required an animal to reach the standard of 1 or less errors in 4 consecutive trials. Since errors of the second order disappear almost altogether during the early trials, the foregoing criteria were based wholly upon errors of the first type (E_1).

c. Percentage of errorless trials. The percentage of each group making errorless scores for Trials 1 to 30 has been tabulated and graphically illustrated.

d. Relative difficulty of alleys. Group comparisons of the relative difficulty of alleys during the first, second, and last third of the training series have been made.

e. Time. Group comparisons are based upon the mean times for each of the 30 trials.

TABLE 3

RELIABILITY OF DIFFERENCES BETWEEN MEANS AND BETWEEN STANDARD DEVIATIONS OF THE DISTRIBUTION OF ERROR SCORES (E_1) ON TRIALS 1-15

Groups	Means: Difference	Means: $\frac{Diff}{P.E._{diff}}$	Standard deviations: Difference	Standard deviations: $\frac{Diff}{P.E._{diff}}$
a vs *b*	3 33	2 33	2 97	2 94
a vs *c*	14 26	5.21	12 78	6 62
a vs *d*	6 91	2 98	9 87	6 02
b vs *c*	10 93	3 81	9.81	4 83
b vs *d*	3 58	1 44	6 90	3 94
c vs *d*	7 35	2 16	2 91	1 21
A vs. *B*	15 14	4 78	5 62	2 51
A vs *C*	22 91	6 56	5 44	2 21
B vs *C*	7 77	2 22	0 18	0 07
a vs. *A*	8 33	3 51	5 50	3 29
a vs. *B*	23 47	9 82	11 12	6 54
a vs *C*	31 24	11 16	10.94	5 55
b vs *A*	5 00	1 98	2 53	1 93
b vs *B*	20 14	7 93	8 15	4 53
b vs *C*	27 91	9 53	7 97	3 87
c vs *A*	5 93	1 72	7 28	3 00
c vs *B*	9 21	2 67	1 66	0 68
c vs. *C*	16 98	4 53	1 84	0 70
d vs. *A*	1 42	0 46	4 37	1 99
d vs *B*	16 56	5 29	1 25	0 56
d vs *C*	24.33	7 05	1 07	0 [illegible]

Results

1. *Means and Standard Deviations of Errors* (E_1) Table 2 gives the means and the standard deviations of the distributions of

TABLE 2

MEANS AND STANDARD DEVIATIONS OF THE DISTRIBUTION OF TOTAL ERRORS (E_1) MADE BY YOUNG AND ADULT ANIMALS ON TRIALS 1-15 AND 16-30

Trials per day	Young animals Group	Young animals Mean	Young animals S.D	Adult animals Group	Adult animals Mean	Adult animals S.D
			Trials 1-15			
1	*a*	44.67±0.18	8.10±0.56	*A*	53.00±2.23	13.60±1.57
3	*b*	48.00±1.18	11.07±0.83	*B*	68.14±2.25	19.22±1.60
5	*c*	58.93±2.62	20.88±1.85	*C*	75.91±2.68	19.04±1.89
10	*d*	51.58±2.18	17.97±1.54			
			Trials 16-30			
1	*a*	14.74±0.84	8.58±0.60	*A*	11.00±1.39	8.51±0.99
3	*b*	9.08±0.84	7.92±0.59	*B*	19.12±2.16	18.42±1.50
5	*c*	12.72±1.31	10.48±0.93	*C*	24.44±2.04	14.49±1.44
10	*d*	12.23±1.37	11.28±0.97			

TABLE 4

RELIABILITY OF DIFFERENCES BETWEEN MEANS AND STANDARD DEVIATIONS OF THE DISTRIBUTION OF ERROR SCORES (E_1) ON TRIALS 16-30

Groups	Means: Difference	Means: $\frac{Diff}{P.E._{diff}}$	Standard deviations: Difference	Standard deviations: $\frac{Diff}{P.E._{diff}}$
a vs. *b*	5.66	4.76	0.66	0.79
a vs. *c*	2.02	1.29	1.90	1.71
a vs. *d*	2.51	1.56	2.70	2.37
b vs. *c*	3.64	2.33	2.56	2.33
b vs. *d*	3.15	1.96	3.36	2.95
c vs. *d*	0.49	0.26	0.80	0.60
A vs. *B*	8.12	3.16	9.91	5.51
A vs. *C*	13.44	5.44	5.98	3.42
B vs. *C*	5.32	1.79	3.93	1.89
a vs. *A*	3.74	2.28	0.07	0.06
a vs. *B*	4.38	1.88	9.84	6.07
a vs. *C*	9.70	4.39	5.91	3.79
b vs. *A*	1.92	1.17	0.59	0.51
b vs. *B*	10.04	4.31	10.50	6.52
b vs. *C*	15.36	6.95	6.57	4.21
c vs. *A*	1.72	0.90	1.97	1.45
c vs. *B*	6.40	2.76	7.94	4.49
c vs. *C*	11.72	4.84	4.01	2.35
d vs. *A*	1.23	0.63	2.77	2.01
d vs. *B*	6.89	2.69	7.14	3.99
d vs. *C*	12.21	4.96	3.21	1.84

errors for Trials 1-15 and Trials 16-30. In Tables 3 and 4 will be found the values of $\frac{Diff.}{P.E._{diff.}}$ by means of which the statistical significance of differences in means and standard deviations may be estimated. For the purpose of this paper we shall consider a ratio of $\frac{Diff}{P.E._{diff}}$ which equals 3 as being suggestive and a ratio of 5 or more as indicative of statistical significance.

Contrasting, first, means of the young groups on Trials 1-15, we find a difference between the 1-trial and the 5-trial group that is statistically significant and in favor of the 1-trial group The difference between the means of the 3- and the 5-trial groups is suggestive of statistical significance. Other differences are too small to be suggestive of statistical significance. As to standard deviations, the

differences between the 1-trial and the 5- and the 10-trial groups are significant and in favor of the former That of the 3-trial group is also smaller than the 5- and the 10-trial groups, but in this case the difference is only suggestive of significance. By inspection of the raw data of these various groups, we learn that the bases for the foregoing differences were laid in the first 8 trials of the learning series

In Trials 16-30 a remarkable shift in difference of means occurs. The 1-trial group now becomes the inferior and the 3-trial the superior group All differences are relatively small, however, and only in the case of the 3- and the 1-trial groups are the differences suggestive of statistical significance. None of the differences between standard deviations for Trials 16-30 are suggestive of statistical significance.

Considering next the adult groups, we find that the difference between means of the 1- and the 3-trial groups for Trials 1-15 is suggestive of statistical significance and the difference between the 1- and the 5-trial groups is statistically significant The difference between means of the 3- and the 5-trial groups is negligible Also differences between standard deviations are insignificant For Trials 16-30, the differences between means noted for the first half of the learning series still hold and the relative standing of groups remains the same For this segment the standard deviation of the 1-trial group is significantly less than that of the 3-trial group. The 1- and 5-trial groups have a difference that is suggestive of statistical significance

Generally speaking, the young are superior to the adults as to mean error scores on Trials 1-15 Although the difference between the young and the adult 1-trial groups is only suggestive of statistical significance, those between the young 1- and the adult 3- and 5-trial groups are certainly statistically significant. The young 3-trial group is significantly better than either the adult 3- or 5-trial group The young 5-trial group is neither significantly poorer nor better than either the adult 1- or the 3-trial groups, but between it and the 5-trial adults the differences are suggestive of statistical significance The young 10-trial group has a mean that is approximately equal to that of the 1-trial adults, but significantly smaller than that of the adult 3- and adult 5-trial groups As to standard deviations on Trials 1-15, only the differences in this respect between the young 1-trial and adult 3- and 5-trial groups are statistically significant Differences between standard deviations of the young and adult 1-trial groups,

the young and adult 3-trial groups, and the young 3- and the adult 5-trial groups, and the young 5- and the adult 1-trial groups are suggestive of statistical significance Other differences are not suggestive of statistical significance.

On Trials 16-30, the superiority of mean-error scores of young over adults is not consistently found and where present is less reliable than that found in the first 15 trials. Differences between the mean of the young 1-trial group and those of the adult 1-, 3-, and 5-trial groups are small and only in the latter case suggestive of statistical significance. The difference between means of the young and adult 3-trial groups is suggestive of significance and that between the young 3- and adult 5-trial groups is statistically significant. Likewise, the difference between the young 10- and the adult 5-trial groups is suggestive of statistical significance. With the exception of the adult 1-trial group, the young groups tend to be somewhat less variable than the adults in the last 15 trials.

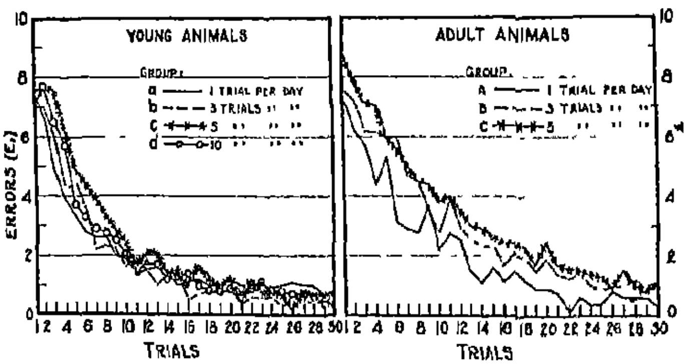

FIGURE 1
MEAN NUMBER OF ERRORS OF TYPE 1 (E_1) MADE BY THE GROUPS OF YOUNG AND ADULT ANIMALS

2. *Error Curves.* Figure 1 graphically illustrates the average number of errors (E_1) made by young and adult groups in their daily trials. From the graphs it is apparent that all performances of the young are very similar or identical after the first 5 or 10 trials. In these trials, the order of superiority, as inferred from the graphs, is as follows: 1-trial, 3-trial, 10-trial, and 5-trial. Beyond the tenth trial overlapping and crossing of curves are the outstanding features,

only a slight and inconsistent superiority of the 3-trial group may be discerned.

Of the adults, the 1-trial group is consistently better than the others, and the 3-trial, in turn, is better than the 5-trial group. With the curves of the young groups, the 1-trial group of adults alone compares favorably at any stage of the learning series All the young and the 1-trial adults at the tenth trial have reached a level similar to that on the twentieth trial reached by the 3- and 5-trial adults. As we have previously shown in connection with Table 2, these differences are statistically significant Hence, beyond doubt, concentration of trials has produced in this experiment a different effect on the progress of maze mastery in adults as compared with young animals trained immediately after the weaning age What the fundamental cause of this difference may be, if other experiments confirm it, is probably a very interesting and important fact for animal psychology

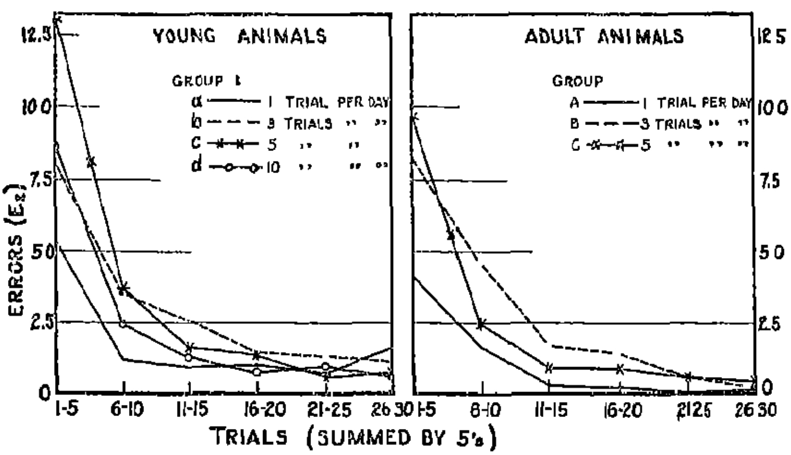

FIGURE 2
MEAN NUMBER OF ERRORS OF TYPE 2 (E_2) MADE BY THE GROUPS OF YOUNG AND ADULT ANIMALS

Figure 2 graphically represents the retracing errors (E_2). Sparcity of errors of this type led us to base the curves on averages for 5-trial segments As the graphs show, concentration of practice beyond 1 trial per day gives rise to an increase of retracing (E_2).

In this connection, retracing is of special interest because it is usually associated with a perceptible increase in the number of forward-going errors (E_1). That is to say, each time an animal retraces, it has an additional opportunity to make an error of the first type as compared with an animal that makes no forward-going error or an animal that corrects its error and thereafter proceeds directly forward on the true path As shown by Figure 2, the 5-trial group retraced more in the early trials than either of the other young groups By actual count we find that the errors of the first type made by it after retracing is larger than that of either of the other groups. Likewise, those of the 10- and the 3-trial groups similarly made are in greater number than those of the 1-trial group. These facts, we believe, led to the slight inferiority of the curves of the 3-, 5-, and 10-trial groups as compared with the 1-trial groups in the first 5 to 10 trials. Accordingly, it seems probable that if the younger groups had been permitted no retracing whatever no difference in their learning curves would have been obtained.

Retracing will not account for the inferiority of the 3- and 5-trial adults shown in Figure 1, however, for the differences in retracing of adults and young are negligible in amount and, furthermore, the errors committed after retracing amount to only a small fraction of the total errors made. In fact their influence on learning curves is hardly perceptible after the first 5 to 10 trials in either young or adult groups. A factor still unknown to us must account primarily for the inferiority of concentrated practice in the adult groups

3. *Trials to Learn.* Since the animals were given only 30 trials, some individuals of each group failed to satisfy the more rigid criteria of mastery advocated by some experimenters. By using less severe criteria and making use of medians rather than means, however, we are able to indicate the relative proficiency of our groups with respect to degree of mastery of this maze in 30 trials. Two criteria have been used; 3 or less errors in 3 consecutive trials, and 1 or less error in 4 consecutive trials. The results derived by applying these criteria to the data of each group are tabulated in Table 5. From a consideration of the data of this table it is apparent that medians of the younger groups do not consistently indicate advantage or disadvantage for either distributed or concentrated trials. Actual differences found are too small to have statistical significance. Excepting the 1-trial group, the adults were less proficient than the young in satisfying the criteria of learning The difference between medians of either

young group and those of the 3- and 5-trial adult groups are statistically significant in each case. These differences are also in harmony with differences of mean-error scores presented in Table 2 and the error curves of Figure 1.

TABLE 5

MEDIAN NUMBER OF TRIALS REQUIRED BY THE GROUPS OF THIS EXPERIMENT TO SATISFY A LENIENT AND A FAIRLY SEVERE CRITERION OF MAZE LEARNING

(Lenient criterion—3 or less errors in 3 consecutive trials, severe criterion —1 or less errors in 4 consecutive trials.)

Group	N	Trials per day	3 or less in 3 trials	1 or less in 4 trials
		Young		
a	47	1	13.2±0.49	21.6±0.95
b	40	3	13.5±0.49	22.5±1.14
c	29	5	15.0±1.16	20.8±*
d	31	10	13.0±1.17	21.3±*
		Adults		
A	17	1	17.0±0.86	23.3±1.38
B	34	3	22.5±1.03	28.0±*
C	23	5	20.9±1.54	30.0±*

*No probable errors calculated for these medians inasmuch as more than one-quarter of the individuals failed to satisfy the criterion, thus rendering impossible the determination of the inter-quartile range.

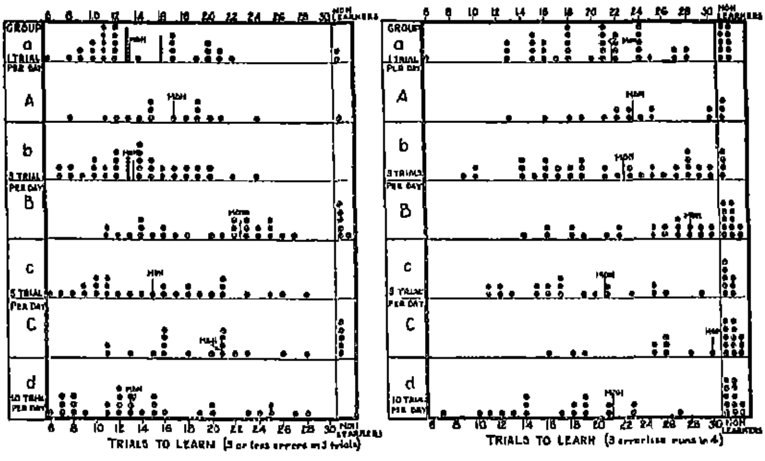

FIGURE 3

NUMBER OF TRIALS REQUIRED BY INDIVIDUAL ANIMALS TO SATISFY A LENIENT AND A FAIRLY SEVERE CRITERION OF MAZE LEARNING

(Those failing to satisfy the criterion in the 30 trials are designated as non-learners.)

Pertinent facts relative to the scatter of individuals satisfying the criteria of mastery are indicated in the scatter diagram of Figure 3. Again the similarity of young groups and their superiority over the adults, excepting the 1-trial group, is indicated by the positions of medians on the scale, and especially noteworthy are the facts that few of the adults approximate the better scores made by the young and that a greater percentage of the adults failed to satisfy the criteria of learning.

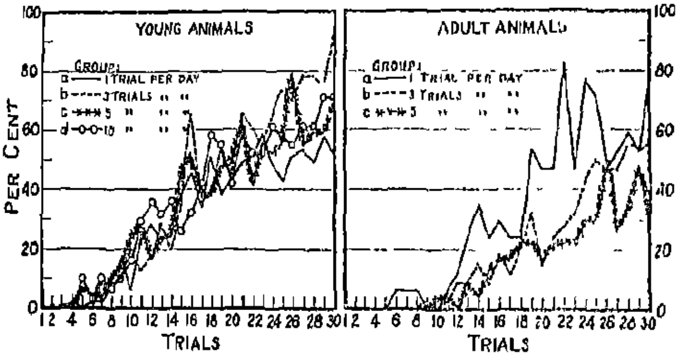

FIGURE 4
PERCENTAGE OF ANIMALS IN EACH GROUP MAKING ERRORLESS RUNS

4. *Percentage of Errorless Trials.* Figure 4 presents the percentage of animals in each of the young and the adult groups making errorless runs on Trials 1 to 30. One should expect that the more important group differences, if any, will appear in the latter half of the trial series when individuals of each group are closely approximating mastery of the maze. Graphs representing the errorless scores for the younger groups show no consistent superiority or inferiority during the first 25 trials; thereafter, the 3-trial group diverges from the others in a direction denoting *superiority and the 1-trial group* diverges in the reverse direction. From a statistical point of view the difference between the 3- and 1-trial groups is significant for Trials 26-30. Measured similarly, the difference between the 5- and 10-trial groups, on the one hand, and their superior, the 3-trial group, or their inferior, the 1-trial group, is not significant. What, we may ask, caused this inferiority of the 1-trial group on Trials 25 to 30? Previous experience with 1-trial animals had led us to expect consistent performances of them in the latter stages of maze mastery,

hence such results were not in accordance with legitimate expectations. Unfortunately we cannot answer the question satisfactorily. Although we have inspected the scanty notes made while the animals of this group were in the final stages of training, nothing of note was found beyond an occasional record of a fear response which was associated on that day with a few errors. Whether fear responses were sufficiently frequent to have caused the obtained difference between the groups in question, however, is doubtful

That the adult groups score fewer errorless runs than the young is evident from a consideration of Figure 4. The 1-trial adult group, however, is only slightly inferior to the younger groups. Among the adults, errorless runs tend to appear in considerable number about 5 or 6 trials later than among the younger groups. On the whole, concentration of daily trials is directly correlated with low percentages of errorless runs among the adult animals

In passing, it is of interest to note that some of the curves of Figure 4 reflect the position of certain trials in each day's series. The curve of the young 5-trial group shows a decided peak on Trials 11, 16, 21, and 26—the first trials of each day's series. With one or two exceptions the same is true of the young 3-trial group, although in this case the divergence between last and first trial is less clearly marked than in the case of the young 5-trial group A slight tendency in the young 10-trial group is also perceivable In the curves of the adult groups no rhythms are apparent.

5 *Comparative Difficulty of Specific Blind Alleys* Of the twelve blind alleys in the maze used in this experiment, numbers 5 and 7 are most frequently entered throughout the trial series, 13, 17, and 19 are seldom entered, and the others occupy stages of intermediate difficulty Will points of relative ease and difficulty remain the same for groups of animals given concentrated and distributed practice? That is a question we have raised in the present study To answer the question, we have calculated the mean number of errors made by each group on each alley in the first, second, and last ten trials The results are graphically represented in Figure 5

Surveying Figure 5 without regard for the results of any particular group, one notes that the points of ease and difficulty are very similar for all groups These results are also in accord with those of previous studies (Weaver and Stone, 12, Stone, 6, 7). Alleys 5 and 21 stand out as being difficult during each third of the trial series, numbers 13, 17, and 19 are the least difficult, and after

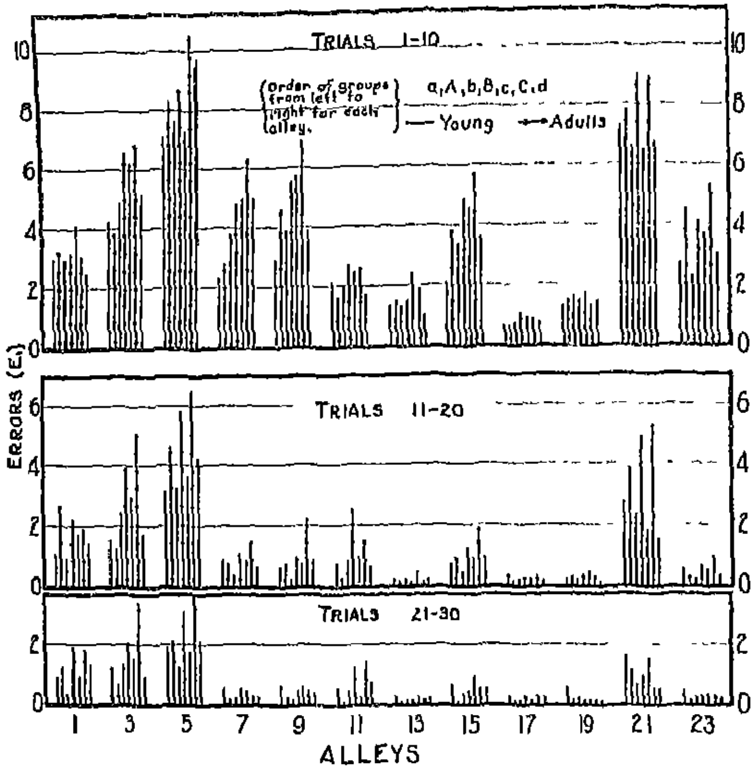

FIGURE 5
MEAN NUMBER OF ERRORS OF TYPE 1 (E_1) MADE ON EACH BLIND ALLEY IN SUCCESSIVE 10-TRIAL SEGMENTS OF THE TRIAL SERIES

the first third of the trial series are seldom entered. Other alleys, as previously stated, occupy intermediate stages of difficulty in the early trials and become clearly differentiated only in the latter stages of the trial series. Of this intermediate group, Alleys 1 and 3, of slightly more than moderate difficulty in the first ten trials, increase their rank of difficulty in the last ten trials where they provoke about as many errors as the more difficult Alleys 5 and 21.

With small groups of animals one is hardly warranted in analyzing the individual differences between groups for the different alleys, since chance plays a heavy rôle where numbers of errors are small. Nevertheless it may be noted that the inferiority of the adult 3- and

5-trial groups is clearly shown in Trials 11-20 and to a lesser degree in the first and last 10 trials. Also it seems fair to predict that the unevenness of mean scores for the young groups would probably be reduced greatly with sizeable additions in the numbers of individuals. We cannot be sure, however, that all differences herein shown would be completely erased.

6 *Time Curves.* There is little justification for stressing time scores in any study of fundamental differences in learning ability associated with distributed and concentrated practice, because time scores are so dependent upon chance factors, rate of locomotion, amount of retracing, etc Yet it is always a matter of interest to know what the results for time scores are in any investigation of this kind Figure 6 graphically illustrates the mean time scores, trial by trial, for the different groups.

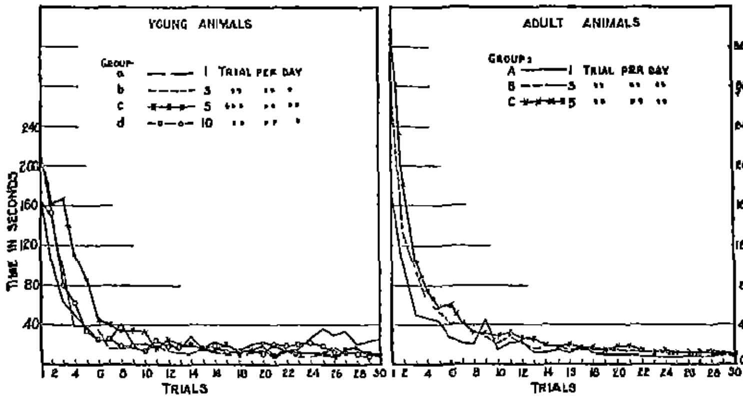

FIGURE 6
MEAN TIME SCORES OF THE GROUPS OF YOUNG AND ADULT ANIMALS

Excepting the first few trials of the young and adults, the maze is run in about the same average time by each group Rates of time reduction and final levels reached are very similar for all In the early trials one finds apparent the influence of retracing in producing inferior time curves for groups in which retracing was relatively prevalent. (See Figure 2) Note especially the curve of the young 5-trial group for an illustration of this point. Similarly, the curves for the adult 3- and 5-trial groups are relatively high during the first 8 trials which corresponds to their relatively high curves for retracing errors.

On the whole, temporal differences associated either with age or with distributed or concentrated practice are too small in this study to receive further consideration. For all practical purposes, if these results are typical, the time factor may be overlooked in spaced and in distributed maze practice for rats.

Correlation with Previous Studies

Experimental studies of the temporal distribution of practice in relation to rapidity of animal learning have been critically examined by Warden (11) and Cook (2) in connection with their own reports of extensive experiments on this subject The results are not in complete harmony, as the articles reviewed clearly indicate, and because of the incomparability of experimental conditions under which these studies were made the more important differences cannot be resolved by inference or speculation. Thus it follows that no final conclusion can be drawn as to the relative merits of the principle of distribution versus massed practice, particularly for the standard practice of allowing one day to intervene between trials or groups of trials

Prior to the report of Cook (2) it seemed probable that some form of distributed practice was almost certain to prove superior in respect to error elimination, trials for mastery, and time consumed in a given number of runs for the standard 1-day interval between practice periods This tentative conclusion is not substantiated, however, by Cook's findings. This experimenter, using a multiple-T maze of eight blinds, large groups of homogeneous and well-conditioned animals, special care as to the minutia of experimentation, and more varied criteria of learning than his predecessors, found that the factor of temporal distribution of trials over a wide range appeared to be unimportant in determining the learning scores obtained. Likewise our present study of young groups, though not strictly comparable in many respects to that of Cook or his predecessors, shows little or no important difference between the temporal distribution of 1, 3, 5, and 10 trials administered with a 1-day interval between trial groups On the other hand, our results with adult animals tend to harmonize with those of Warden who, using one of the Carr mazes, found that a single trial per day was superior to 3 or 5 trials.

Differences in conclusions reached by different experimenters would seem to be inevitable since in these studies one finds individual rather than common methods of motivating animals, subjects of dif-

ferent ages, large groups and small groups, mazes differing in patterns and number of difficult points, adequate and inadequate preliminary training, uncorrelated and highly correlated criteria of learning, a maze with but one choice, one that calls for decision at cross roads, one that emphasizes timing rather than direction of turns, a maze that inhibits and mazes that permit retracing ad libitum, to say nothing of differences arising from purely chance factors and leading to erroneous impressions as to the general consistency of results. Even the views recently voiced by Cook (2) to the effect that massed practice may be more efficient than distributed practice when very simple mazes are used hardly seems warranted, for the data of Lashley (4), though not strictly comparable, would seem to be in opposition to that of Pechstein (5) on which the opinion of Cook is founded. Likewise we may seriously question the force of Cook's explanation of differences between his own and the conflicting results of Ulrich (10) and Warden (11) resting as it does upon the assumption that his straightaway, 8-unit, T-maze is one of intermediate difficulty in comparison with the Watson circular and the Carr square maze employed respectively by Ulrich and Warden So far as the authors know, there is no acceptable method for determining the relative difficulty of mazes, as measured on a commensurate basis, from published reports of different workers whose studies embody individual techniques of training animals, different criteria of mastery, and other variations known to affect the magnitude of learning scores. Moreover, in our opinion, only suspended judgment is warranted as to the cause either of harmony or discordance in published reports until other variables inherent in this intricate problem have been systematically weighed as to their relative potency in determining the magnitude of learning scores

Meanwhile it seems legitimate to stress for the present a tentative gain of immense practical value that may have come from the study of Cook and the present one Where indicated by the requirements of practical situations, one may employ a method of massed practice with young animals between the ages of one and two months (probably somewhat older) on multiple-T mazes of 8 to 12 alleys with good reason for believing that the learning scores will differ in no important respect from those which might have accrued from a single trial per day Since mazes of this type are known to yield very reliable scores, as measured by conventional methods (Tolman and Nyswander, 9, Stone and Nyswander, 8; and Husband, 3), the

scores obtained from massed practice with young animals trained on these mazes would seem to meet many of the requirements of present-day rat experiments.

Summary and Conclusions

In this study we have assessed the relative merits of massed and distributed practice in young and adult rats that were trained on a 12-blind, multiple-T maze. Four groups of young, approximately one month of age, were given 30 trials at the rate of 1, 3, 5, and 10 trials daily, and three adult groups were given the same number of trials at the rate of 1, 3, and 5 trials per day. The obtained results would seem to warrant the following statements:

1. *Errors* On Trials 1-15 the young groups differ among themselves only slightly as to mean and variability of total errors made while running toward the goal. Slight differences occurring in the first 5 to 10 trials are not directly correlated with massing of trials. On Trials 16-30 differences are very small and are not correlated with the factor of distribution of practice. In the three adult groups massed practice is directly correlated with error scores. Young groups are greatly superior to the adult 3- and 5-trial groups on Trials 1-15 and somewhat superior to them in the second half of the trial series as well

2 *Retracing* Massing of trials in young and adult groups beyond one trial per day is associated with an increase in retracing, particularly in the first 5 to 10 trials. Thereafter differences are small and are not directly correlated with massing of practice.

3. *Trials to learn.* No significant differences between the massing of practice and the trials required to satisfy two criteria of mastery were found between the young groups. Likewise, there was no significant difference between the adult 1-trial and any of the young groups in trials to learn. The 3- and 5-trial adults, however, required more trials to satisfy the criteria of mastery than the adult 1-trial or any of the young groups

4. *Percentage of errorless runs* There is no significant relationship between the massing of trials and the percentage of errorless runs made by young animals during the first 25 trials; in the last five trials, however, the 1-trial young group was significantly inferior to the 3-trial group, but neither of these was significantly different from the 5- and the 10-trial groups. The 1-trial adults were only slightly inferior to the young groups, but the 3- and 5-trial adults

were significantly inferior to the young On the whole, low concentration of practice is significantly associated with a large number of errorless runs only in the adult groups

5. Points of relative ease and difficulty are approximately the same in this maze irrespective of age groups or massing of trials per day.

6. Excepting the first 4 to 10 trials, the mean time for running the maze was approximately equal for each group of young and adult animals In the early trials the 1-trial groups were superior to any of the other groups. The greater numbers of retracings by groups having massed practice probably accounts chiefly for the differences in times in early trials When retracing differences became insignificant, time differences likewise disappeared.

7 Close concordance of this study with the recent report of Cook (2) on this subject would seem to justify the tentative conclusion that with rats of one to two months of age one may mass practice within wide limits on multiple-T mazes without greatly affecting the rate of mastery.

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L'EFFICACITÉ RELATIVE DE LA PRATIQUE DISTRIBUÉE ET NON DISTRIBUÉE DANS L'APPRENTISSAGE DU LABYRINTHE PAR LES RATS BLANCS JEUNES ET ADULTES

(Resumé)

Dans cette étude on a estimé les mérites relatifs de la pratique distribuée et non distribuée chez les rats jeunes et adultes entraînés dans un labyrinthe multiple-T, comprenant 12 culs-de-sac. On a fait subir à quatre groupes des jeunes âgés d'environ un mois trente épreuves avec 1, 3, 5, et 10 épreuves par jour, et on a fait subir à trois groupes des adultes le même nombre d'épreuves avec 1, 3, et 5 épreuves par jour.

Les résultats obtenus des quatre groupes des jeunes ne montrent que très peu de rapports ou nuls rapports entre la concentration des épreuves et le nombre des erreurs en avant, les épreuves nécessaires pour satisfaire les normes données de maîtrise, le pourcentage des parcours sans erreur faits par les groupes, et la difficulté des sentiers spécifiques dans le labyrinthe. Un accroissement des retracements a résulté de la concentration des épreuves au-delà d'une par jour pendant les 5 à 10 premières épreuves; après cela, les différences des retracements ont été petites et probablement de nulle signifiance. Pendant les premières épreuves, pendant que les retracements ont été les plus fréquents, les groupes des jeunes entraînés avec les épreuves non distribuées ont mis plus de temps pour chaque épreuve que les groupes subissant à une épreuve par jour. Au-delà du premier tiers de la série des épreuves, cependant, toutes les différences des courbes de temps sont devenues insignifiantes et avec nulle corrélation avec la pratique non distribuée.

Chez les groupes adultes, on a trouvé une corrélation directe des épreuves non distribuées avec le nombre des erreurs en avant, des retracements, et le nombre des épreuves nécessaires pour satisfaire les critères de maîtrise; et une corrélation inverse avec le pourcentage des parcours sans erreur. Pendant les 10 premières épreuves quand la concentration des épreuves a causé plus de retracements les groupes de 3 et de 5 épreuves ont une durée moyenne plus grande que celle du groupe d'une épreuve; dans les derniers deux tiers de la série des épreuves cette différence devient relativement petite et probablement insignifiante.

Sans égard au degré de distribution des épreuves, les jeunes groupes ont été supérieurs aux groupes adultes de 3 et de 5 épreuves; ils ont été aussi un peu supérieurs, mais non d'une façon signifiante, au groupe adulte d'une épreuve pendant la première moitié de la série des épreuves.

Mayer et Stone

DIE RELATIVE WIRKSAMKEIT VERTEILTER UND KONZENTRIERTER ÜBUNG BEI DER ERLERNUNG EINES LABYRINTHES DURCH JUNGE UND ERWACHSENE ALBINORATTEN

(Referat)

In dieser Untersuchung haben wir die relativen Vorzüge von verteilter und konzentrierter Übung abgeschätzt an *jungen* und *erwachsenen* Ratten die in einem multiplen T-Labyrinth ("T" maze) mit 12 Sackgassen trainiert worden waren. Vier Gruppen von Jungen, etwa 1 monat alt, wurden 30 Proben unterworfen, bei 1, 3, 5, oder 10 Proben täglich, und drei Gruppen erwachsener Ratten wurden der selben Probezahl unterworfen, bei 1, 3, und 5 Proben täglich.

Die an den vier jungen Gruppen erzielten Resultate zeigten fast kein Verhältniss zwischen der Konzentrierung der Proben einerseits und der Zahl der progressiven Fehler ('forward-going errors'), der zur Befriedigung bestimmter Normen der Meisterschaft nötigen Proben, dem Prozent der von der Gruppe gemachten fehlerlosen Fahrten, und der Schwierigkeit spezifischer Alléeen in dem Labyrinthe anderseits. Die Konzentrierung der Proben über eine Probe per Tag hinaus brachte während der ersten 5 bis 10 Proben eine Erhöhung der Zahl der Wiederbetretungen ('retracings') herbei, danach waren die Unterschiede in der Zahl der Wiederbetretungen klein und wahrscheinlich ohne Bedeutung. Im Laufe der früheren Proben, während die Wiederbetretungen am häufigsten waren, gebrauchten die jungen, mit mehreren täglichen Proben trainierten Ratten mehr Zeit per Probe wie die Gruppen die täglich nur *eine* Probe durchmachten. Über den ersten Drittel der Probeserie hinaus wurden alle Unterschiede in den Zeitkurven bedeutungslos und zeigten mit der Konzentrierung der Übung kein Verhältniss mehr.

In den Gruppen der erwachsenen Ratten zeigte sich eine direkte Korrelation zwischen der Konzentrierung der Proben einerseits und der Zahl der progressiven Fehler, den Wiederbetretungen, und der Zahl der zur Befriedigung bestimmter Normen der Meisterschaft nötigen Proben anderseits, mit dem Prozent der fehlerlosen Fahrte war die Korrelation invers. *Während der ersten 10 Proben, als die Wiederbetretungen durch Konzentrierung der Proben vermehrt wurden, brauchten die 3- und die 5-probigen Gruppen durchschnittlich mehr Zeit per Probe wie die 1-probige Gruppe (the 1-trial group). In den letzten zwei Dritteln der Probeserie wird dieser Unterschied verhältnissmässig klein und wahrscheinlich unbedeutend.

Abgesehen von dem Grad der Konzentrierung der Proben waren die jungen Gruppen den erwachsenen 3- und 5-probigen Gruppen überlegen, sie waren auch etwas, aber nicht bedeutend, der erwachsenen 1-probigen Gruppe während der ersten a Hälfte der Probeserie überlegen.

MAYER UND STONE

THE DOUBLE ALTERNATION PROBLEM: I. THE BEHAVIOR OF MONKEYS IN A DOUBLE ALTERNATION TEMPORAL MAZE*[1]

From the Psychological Laboratories of Clark University

LOUIS W. GELLERMANN

INTRODUCTION

The problem of double alternation in the temporal maze apparently requires for its solution the utilization of symbolic processes. This position was originally outlined and investigated experimentally by Hunter in connection with his study of the kinaesthetic sensory processes in the rat (3, 4). The results of that study indicated that the rat could not master the double alternation problem in the temporal maze unless aided by spatially arranged cues. Hunter also tested raccoons in the double alternation temporal maze (5) and found that these animals gave evidence of being able to perform the problem without the aid of exteroceptive cues Thus rats and raccoons were found to have the same relative abilities in the double alternation problem as had previously been found for them (by Hunter, 2) in the delayed reaction problem Another investigation in which the double alternation temporal maze has been used by Hunter relates the problem of the sensory control of the maze habit (in the white rat) to the problem of double alternation in bidimensional, tridimensional, and temporal mazes (6). These studies all support the hypothesis of symbolic processes in explanation of successful performance of the double alternation temporal maze. As Hunter (6, p. 535) states, "The mastery of the double alternation temporal maze is apparently only possible for an animal who can supplement proprioceptive and exteroceptive stimuli with some sym-

*Accepted for publication by Walter S Hunter of the Editorial Board and received in the Editorial Office, December 17, 1930

[1]Other papers in this series to appear in the *Journal of Genetic Psychology* are: II "The behavior of children and human adults in a double alternation temporal maze," and III "The behavior of monkeys in a double alternation box-apparatus."

The writer takes pleasure in expressing his indebtedness to Dr Walter S. Hunter of Clark University, under whose direction these experiments were conducted The actual experimental work described in the present paper was conducted daily from December 6, 1928, to March 22, 1930

bolic process or with some central neural process." Whether these central processes are representative of the general pattern of the responses to be made in the maze or of the cumulative effects of the successive trips in the maze is not known.

The present series of experiments is a further analysis of double alternation with reference to symbolic processes, using monkeys and human subjects. These subjects were tested on the double alternation problem in the temporal maze, and their behavior under these conditions was carefully observed and recorded. Monkeys were tested also in a new apparatus called the alternation box-apparatus, which is original with this investigation. As a result of these experiments it is possible to compare the double alternation behavior of monkeys and human subjects with that of rats and raccoons. Furthermore, the behavior of the subjects used in the present investigation has been analyzed for its own sake. Out of the total treatment a clearer understanding of the nature of double alternation behavior has arisen.

Purpose of Experiment 1

As stated above, Hunter found the performance of raccoons to be superior to that of rats, both in the double alternation temporal maze (5) and in the delayed reaction experiment (1). The ability demonstrated by raccoons in the latter problem indicates that they possess only "the bare rudiments of symbolic processes," and the work with the former problem indicates that they were able to learn the double alternation of four responses, *R R L L*, only with great difficulty. Since Tinklepaugh (7) has found that the monkey is superior to the raccoon in the delayed reaction experiment, it appeared likely that the monkey could learn the double alternation temporal maze with relatively great facility. The present experiment was devoted to the study of this problem. In particular it seeks to answer experimentally the following questions:

1. Can monkeys learn the double alternation of four responses, *R R L L*, in the temporal maze?
2. Can monkeys extend the double alternation of responses to a series of greater lengths than that upon which they were trained?

Apparatus

Figure 1 presents a ground plan of the temporal maze used in the present experiment. This is the same maze used by Hunter in his

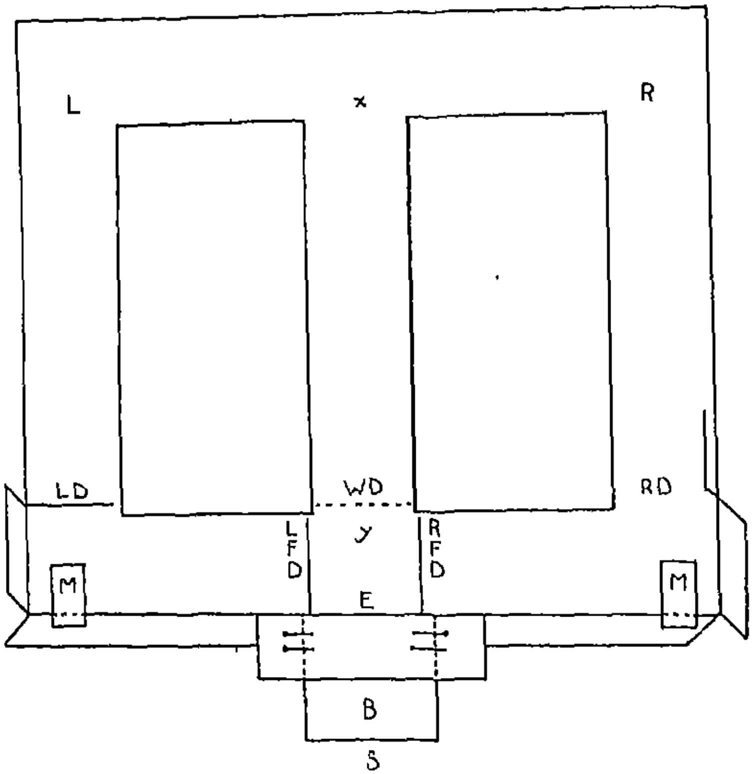

FIGURE 1
GROUND PLAN OF TEMPORAL MAZE
(Details described in the text)

study of double alternation with raccoons, adapted to work with monkeys by means of certain alterations and additions. At the front of the apparatus was an entrance box, *B*, with ¼"-mesh wire covering The front side of this box was a wire door hinged by the top edge. An aperture through this door was used by the experimenter in chaining and unchaining the monkeys during the early stages of experimentation *E* designates a sliding panel which was lifted to allow the animal to proceed from *B* into the maze.

The doors *LD*, *LFD*, *RFD*, and *RD* (left door, left front door, etc.) were hinged to the outside wall of the apparatus. They were controlled from one central point at the front of the maze by means

of a system of levers and rods. Heavy felt pads were placed upon the doors to prevent any jar when the doors were closed. In actual operation the doors could be opened and closed noiselessly. In the center alley of the apparatus was a wire door (represented by the dotted line *W D* in Figure 1) which was hinged to the wire-top frame This door was used at the conclusion of each trial to prevent the animal re-entering the back portions of the maze When not in use it was swung up close to the wire top of the center alley.

Mounted vertically along the front top edge of the apparatus was a wall board screen (9′ x 4′) to prevent the subject's getting visual cues from the experimenter A small observation hole through the

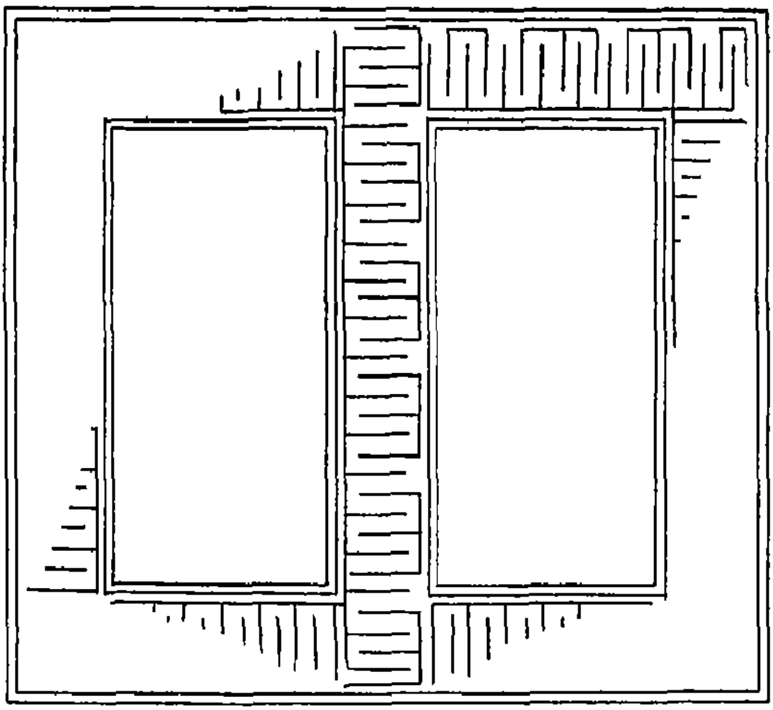

FIGURE 2
ARRANGEMENT OF SHOCK GRIDS IN THE TEMPORAL MAZE

center of the screen enabled the experimenter to view the center alley of the maze. Upon the upper corners of the screen were mirrors (*M* in Figure 1), by means of which the experimenter could view either side alley from a point in front of the observation hole. The experimental room and apparatus were illuminated solely by electric lights. These were shaded in order to minimize the amount of light reflected by walls and ceiling to the portion of the room occupied by the experimenter. The glare of the lights presumably made it difficult for the monkeys to receive visual stimulation from the experimenter through the mirrors.

During part of the experiment electric shock was used instead of hunger to secure regular movement of the subjects through the maze. Figure 2 shows the arrangement of the shock grids on the floor of the apparatus. These grids were made of narrow brass strips fastened on boards. As may be seen in the diagram, the floor grids were in sections. This made it possible to shock the animal at any desired point in the maze. Furthermore, it was possible to bring the shock up to the animal from one side or another and thus partially to direct his movement. At no time, however, was the shock used to influence the response of any subject from point *x*. The shock was administered by an electric stylus and a keyboard of contact points arranged in essentially the same order as the sections of shock grids. The strength of shock was regulated by means of a rheostat shunted into the ordinary 110-volt electric light circuit. No shock was used in the floor grids of sufficient strength to be discriminated by the experimenter. The top wire covering of the maze was also connected with an electric circuit to discourage the subject's climbing in response to shock from the floor grids. In this the second contact points were secured by placing brass strips on the walls of the apparatus at the points where climbing behavior occurred.

Method

1. *Subjects.* Three young Macacus rhesus monkeys were used in this study. They were obtained from the Benson Animal Farm at Nashua, New Hampshire, where they had arrived from India six months before. When we received them in October, 1928, they were probably about one year old. The group included one female called Sis, and two males called Bones and Burt. Unfortunately Burt died after completing only 50 trials. Bones and Sis were in good health during the entire experiment.

2. *Preliminary Training* For a month preceding preliminary trials the monkeys were taken into the experimental room daily in order to accustom them to the surroundings in which they were to work. Here they were at first fed bits of apple, grapes, or a little barley, and later all of their food. They soon learned to enter the room readily and to go to the positions at which they were chained during feeding. Immediately preceding the preliminary trials several days were devoted to teaching the monkeys the routine of entering and leaving the entrance box. Each animal went through this procedure once a day before being fed. The animals could be placed in the entrance box and unchained without difficulty, but at first they resisted being rechained. On the day before his first preliminary trial each monkey was permitted to enter the temporal maze. All the doors of the apparatus were open, and the subjects could have gone through it without restriction However, they went only as far as the point *x* where they sat looking about until they were permitted to come out of the apparatus Three preliminary trials were given which were intended to acquaint the subjects with (*a*) the interior of the maze, (*b*) the operation of the maze doors, and (*c*) the presentation of food. The procedure during the preliminary trials was as follows At the time the subject entered the maze the front doors (*RFD* and *LFD*) were closed, and the side doors (*RD* and *LD*) were open. The first response at *x* could be either *R* or *L* in that the subject could go to the front of the apparatus either way When the subject did come to *F* (to the front) on either side, the door on that side was closed behind him, he was given a bit of food, and the appropriate *FD* was open to permit him to go through the center alley to *x*. He must now go to the other side to get to *F* since the door on the side to which he had just gone was closed Following the second bit of food, the subject was removed from the apparatus Thus a preliminary trial consisted of two responses from *x*, which might be either *R L*, or *L R* This plan was adopted to prevent the establishment of position habits

3 *Explanation of Terms.* Before describing the procedure used during the regular experimental work, I will explain some of the terms to be used The double alternation problem in the temporal maze consists in a series of *R* and *L responses* (choices) from the point *x*, that is, trips to the right and left sides of the apparatus from *x* However, all trips from *x* to the *R* or *L* are not called responses In order to be called a response a trip to the side of the apparatus

from the point *x* must follow a trip up the center alley from *y*. Each response begins with the trip up the center alley and ends when the subject has come to *F*. From *F* he is permitted to go up the center alley again and make another response. All *trips from the point x* were recorded, but only those *were called responses which first followed entrance to the maze or the completion of a trip around one side of the maze.* A *trial* consists of a series of such responses. In the present experiment four responses constituted one trial. In each trial those responses are called correct which conform to the order *R R L L*. An *error* under these conditions designates a response which does not conform to this order. Retracing (except from either back corner of the maze to *x* following an incorrect response), climbing, going back and forth in the center and back alleys, and trips to closed side doors are all called *extra moves* through the maze. A *correct trial* is one in which all responses conform to the order stated above. Since extra moves in the maze are not defined as errors they could be included in a correct trial. In practice, however, extra moves did not appear during correct trials.

4. *Procedure.* The procedure during the regular trials was as follows: The subject was permitted to enter the maze through the door *E*, and was kept in the maze until he had made four trips around the side and front of the apparatus in the order *R R L L*. Thus his problem consisted in making four responses from the point *x* following each of the four trips up the center alley. If he made the correct responses he would find the side doors opened, and could come to *F* at once; if not, he would encounter closed side doors, and would have to retrace to *x* and go to the other side and so to *F*. In each case he must go from *x* to the correct side and *F* before he could return to *x* by way of the center alley for the next response. The right side door was open at the start of the trial. Each time the subject came to *F* the side door was closed behind him, he was given a bit of food, and the front door was opened for him to go into the center alley, and closed behind him as soon as he did so. Grapes were used as food and were allowed to roll from the experimenter's fingers into the front sections of the maze. The experimenter's fingers did not come within view of the subject, and it is improbable that the subject could receive cues from the food. The appropriate side door was opened for response 2, 3, and 4 *only after the subject had made his response from point x*. A response was counted *R* or *L*

only when the animal went from x completely out of the experimenter's view.

5. *Daily Routine* Each animal was given one trial per day, except that Sis near the end of the experiment was given two trials per day. During the first six months of work Sis and Bones were in the experimental room together, because they seemed to work better under these conditions than when they were alone. While one was in the apparatus the other was chained to the wall in one corner of the room Upon completion of a trial the subject was given a small amount of food in the entrance box and then rechained to the wall After both animals had finished work, they were fed in the experimental room This latter practice was discontinued after the first two months and the animals were returned to their living cage for the bulk of their food. The animals were sometimes overfed, with the result that they would work only poorly, if at all, on the next day. This condition finally led to the substitution of punishment (in the form of electric shock) for hunger as a stimulus to movement On those days when a subject did not complete his third response by coming to F and receiving food within a reasonable time, work was discontinued. Such incomplete trials were not counted In all cases where three responses were completed, work was continued until a fourth response, and thus a complete trial was secured.

The criterion of learning was three errorless trials in succession. Various controls used in an attempt to detect possible external cues will be described later

After placing each animal in the entrance box, the experimenter sat at point S (see Figure 1) Complete records were taken of the behavior of each subject These included: (a) responses from x, (b) complete detail of path followed; (c) detail of any other behavior such as hesitation at x, pauses at various points, climbing, sounds, etc , and (d) a cumulative time record of each completed response and the more definite of the items listed under c

RESULTS

1. *Learning*

a. Behavior typical of successive stages in learning During the trials in which the monkeys were learning the problem three general stages of behavior appeared It is particularly interesting to note these in some detail because the same types of behavior and the same

general stages appear with human subjects, as will be shown in the second paper of this series.

In the first stage the subjects paused a great deal, made numerous extra moves, and were timid in relation to the apparatus. More of their time was spent in pauses and delays than in moving about. Following an erroneous response they would go to the closed side door and push and pull at it. They often came to *y*, and pushed on both front doors They also walked back and forth across the back of the apparatus many times. This may have been due in part to their timidity at the movement of the side doors The monkeys were somewhat startled when first the doors were closed behind them as they came into *F*. Sometimes they would rush back past a closing door and go to *x* There would then ensue a period in which the animals delayed in coming down the side alley to *F* They would come very slowly to the side door and feel of it or swing it a little If the experimenter moved the door or made the slightest noise, the monkeys would retreat to *x*. This period of habituation in running the maze took much longer with monkeys than is typical for such animals as rats and raccoons

In the second stage the subjects walked continuously and eliminated extra movements through the maze. At first they would turn back after coming only part way forward toward a closed side door. Later they would turn back as soon as they saw the closed side doors. Trips to *y* and back and forth across the back alley also were eliminated gradually. With these changes in behavior, definite series of responses appeared and persisted for several consecutive trials. During the first stage over 50% of the responses had been incorrect, and there was little similarity in the series of responses from trial to trial. In the second stage all the subjects began to respond *R L L R*, trial after trial. Although not apparent at first glance this is really behavior of a simple alternation type. (See p. 62.)

In the third stage the subjects shifted from one fixed series of responses to another more nearly like *R R L L*. This change was accompanied by hesitation behavior immediately preceding the particular response in the series which was undergoing correction. The first change of this type was usually from *R L L R* to *R L L L*. Preceding the last response of each trial during the time this change was taking place, one of the following types of behavior might appear a slight hesitation, marked hesitation, or slight pause before reaching *x*; hesitation, swaying from side to side, pause, starting

toward R or L and stopping, turning completely around, or looking toward the front of the apparatus from x, and lastly, going toward but not completely to the side alley, or going toward a side so that part of the body but not all of it left the center alley. Immediately preceding the solution of the double alternation problem (changing $R\,L\,L\,L$ to $R\,R\,L\,L$), these types of behavior appeared very definitely in the second response of each trial

Since the change from one stage of learning to another occurs gradually, it is difficult to state definite criteria for the three stages In general, however, transition from the first to the second stage is marked by the disappearance of extra moves through the maze, and the appearance of hesitation behavior preceding responses indicates the beginning of the third stage.

TABLE 1
DATA ON TRIALS FOR DIFFERENT SUBJECTS

Subject	Trials before first correct run	Trials before 3 correct runs in succession*	Total number of trials
Bones	15	80	100
Sis	47	315	500
Burt	16	(never)	50

*Both Sis and Bones actually made five correct runs in succession at the time they satisfied the criterion of learning Work with Burt was interrupted by his illness and death

b Quantitative data on learning Let us now consider the way in which the monkeys learned the double alternation temporal maze in terms of trials and correct responses in each successive group of 10 trials Table 1 shows the number of trials before the first correct run, the number of trials required for learning (3 correct trials in succession), and the total number of trials given each subject Following learning, Bones was given 20 trials, all of which were correct. The controls introduced during some of these trials will be described later Sis received 185 trials following learning of which 52 were correct. Among these were one group of six, three groups of five, four groups of three, and five groups of two successive correct trials The reason why Sis did not master the problem as definitely as Bones did will be presented later With Burt, it was possible to complete only 50 trials of which numbers 17, 49, and 50 were correct Although his last two trials were correct, it is unlikely that he had learned the problem

Table 2 records the number correct in each successive group of 40

TABLE 2

NUMBER OF CORRECT RESPONSES IN EACH SUCCESSIVE GROUP OF TEN TRIALS BEFORE THE INTRODUCTION OF SHOCK GRIDS INTO THE MAZE
(40 responses in each group)

Bones Trials 1 to 98	Sis Trials 1 to 104	Burt Trials 1 to 50
23	17	13
27	17	25
26	18	23
25	19	20
25	22	25
28	22	
30	23	
29	25	
——	28	
40	27	
32 of 32	12 of 16	

responses (i.e., in each successive group of 10 trials) for the period of the experiment during which there were no shock grids in the maze. The line in Bones' record shows the point at which he learned the problem. Sis made steady progress during this period and had begun regularly to make three out of four responses correct (*R L L L*) in each trial.

At this time the shock grids were introduced into the apparatus. Bones had developed the habit of stopping work following his fourth response He would go to the back left corner of the apparatus and remain there. Only rarely would he come to *F* following his fourth response. It was impracticable to attempt to increase for him the number of responses per trial until some means of keeping him moving had been provided. (See page 67) Sis also presented a problem at this time in that she had begun to take more time per trial than formerly and in that she often refused to work altogether During the last 22 days of the first period of experimental work it had been possible to complete only 13 of her trials. The reason for this change in behavior is uncertain. An attempt was made to increase her hunger, but this did not seem to improve her work. Rather, it resulted in an increase in the amount of time she spent sitting still. To obviate these difficulties, I decided to install electric grids in the apparatus and use punishment to keep the animals moving. Watson (8) has suggested that electric shock is superior to certain other forms of punishment for use with monkeys. It seemed quite desirable to make the change from hunger to punishment if this

were possible. The arrangements for the use of shock have already been described (See p 54)

After the installation of the shock grids, Bones completed two correct trials (making 20 successive perfect trials) and refused to work thereafter. On the second of these trials (upon being shocked for the first time) he jumped to the wire top of the apparatus Here he went through the maze correctly without again coming to the floor. To prevent such behavior, a relatively strong shock was arranged in the wire covering of the maze. When Bones received a shock from this source, he became so badly upset that further work with him proved impossible. So far as he was concerned, the shock grids did not succeed in serving the purpose for which they were intended. With Sis the results obtained with shock were as successful as those with Bones had been disturbing Both her series of responses and her time records were temporarily upset, but she

TABLE 3

NUMBER OF CORRECT RESPONSES FOR SIS IN EACH GROUP OF TEN TRIALS FROM THE INTRODUCTION OF SHOCK INTO THE MAZE UNTIL LEARNING† AND FROM LEARNING UNTIL THE CLOSE OF THE EXPERIMENT
(40 responses in each group)

During trials 105 to 315	During trials 316 to 500
14 of 24	20 of 20
21	31
21	*25
26	30
27	36
28	27
25	29
*22	30
25	30
27	
29	31
28	30
29	28
25	36
26	34
28	33
28	33
30	35
29	33
32	34
31	34
14 of 20	

†Mastery required 12 correct responses out of 12, i e , a correct trial on each of three successive days

quickly learned to keep walking in response to shock. The first signs of this adaptation appeared on the second day shock was used. Sis climbed to the wire top as Bones had done, but after receiving one shock from the top wire she never climbed again in 391 trials (After his first experience Bones had avoided shock from the top wire by not touching the second contacts on the wall.)

Table 3 records for Sis the number correct in each successive group of 40 responses (i e, in each successive group of 10 trials) after the shock grids had been installed in the apparatus. The records in the first column are for the period from the introduction of shock to the point of learning; those in the second column are for the period from the point of learning until the close of the experiment The line in the second column indicates the point after which two trials were run each day (7 A M. and 7 P M). The table shows that in the first 26 trials following the introduction of shock Sis made about the same number of errors as correct responses A comparison of the first column of this table with records for Sis in Table 2 indicates that, following the introduction of shock, it took about 100 trials for Sis to reach permanently about the same level of performance that she had reached before the change in method From one standpoint, much of the learning in the first 104 trials of the experiment was dissipated for Sis by the introduction of shock Sis formed a left position habit from Trials 173 to 193 and a right position habit from Trials 329 to 341 (Hunter 2, p. 216). The effect of these position habits is shown in Table 3 at the points indicated by asterisks. No special effort was made to break down these position habits as they appeared inevitable in the temporal maze Sis made 8 correct trials in all throughout the 315 learning trials.

c Simple alternation behavior It has been stated that in the second stage of learning each of the subjects tended to make the series of responses *R L L R* trial after trial. This was the first fixed series of responses with each animal. In it the first and third responses are correct. This type of trial has been called "alternation after success" by Hunter (2, p 216; 4, p. 1, 6, p. 531). This expression is descriptive of the order of responses as technically defined in the double alternation problem (see p 55), but it does not give a clear description of the behavior of the subject in the maze This order of responses may well be spoken of as a *simple alternation* of trips from the point *x* toward the sides of the apparatus. The first time the subject comes to *x* he goes to the *R* (in

the series under discussion) The next time he goes to the *L*, but must retrace to *x* and go to the *R*. On the third response he goes *L*. On the fourth he responds *R*, but again he must retrace to *x*, and go *L*. If the reader will glance back over this series of trips from *x* to the sides of the maze, he will see that the order has been ***R L R L R L***, or simple alternation. (The trips which, under the conditions of the double alternation problem, are called responses have been boldfaced.) It appears, therefore, that the subjects fall into a type of simple alternation, and that learning in the double alternation temporal maze consists partially in breaking down this type of behavior.

TABLE 4
PERCENTAGE OF ERRORS MADE BY EACH SUBJECT ON EACH OF THE FOUR RESPONSES DURING LEARNING

Subject	Responses 1	2	3	4
Bones	1.3	92.7	10.1	30.1
Sis	16.0	94.7	5.8	29.6

TABLE 5
PERCENTAGE OF ERRORS MADE BY EACH SUBJECT DURING EACH TENTH OF LEARNING (AND FOR COMPARABLE PERIODS THEREAFTER) ON EACH OF THE FOUR RESPONSES

Tenth of learning	Bones Responses 1	2	3	4	Sis Responses 1	2	3	4
1	12.5	87.5	37.5	25.0	61.9	90.5	19.0	54.0
2	0.0	62.5	12.5	62.5	20.6	96.8	6.3	63.5
3	0.0	87.5	37.5	37.5	0.0	100.0	3.2	44.4
4	0.0	89.5	0.0	37.5	9.5	90.5	19.0	44.4
5	0.0	100.0	0.0	50.0	12.7	96.8	3.2	22.2
6	0.0	100.0	12.5	50.0	41.3	100.0	6.3	6.3
7	0.0	100.0	0.0	0.0	19.0	100.0	0.0	3.2
8	0.0	100.0	0.0	25.0	3.2	96.8	0.0	34.9
9	0.0	100.0	0.0	12.5	0.0	90.5	0.0	19.0
10	0.0	100.0	0.0	0.0	0.0	87.3	3.2	6.3
	0.0	0.0	0.0	0.0	0.0	9.5	30.2	54.0
	0.0	0.0	0.0	0.0	0.0	63.5	11.1	25.4
	0.0	0.0	0.0	0.0	0.0	52.4	9.5	34.9
					0.0	33.3	19.0	34.9
					0.0	28.6	6.3	25.4
					0.0	14.5	0.0	50.9

d. Relative difficulty of responses. The relative difficulty of the responses in the series *R R L L* is indicated in Table 4. This table

shows clearly that the second and fourth responses on each trial were the most difficult responses and that a great many more errors were made on the second than on the fourth. This is consistent with the fact that the series of responses *R L L R* changed to *R L L L* during the third stage of learning, as has been stated above.

Table 5 records the percentage of errors made by each subject during each tenth of learning (and for comparable periods thereafter) on each of the four responses. With Bones all trials after the twenty-fifth were either *R L L R* or *R L L L* (except Trial 41, *R L R L*) and after Trial 60 all of these but one were *R L L L* until learning. Bones learned the responses of each trial in the order 1-3-4-2. *With Sis somewhat the same course of learning took place.* Her predominate series of responses for the last 100 trials of learning was also *R L L L*, although on 18 trials the responses were *R L L R*. *Following learning Bones made no errors, but Sis continued to do so.* Her major difficulty following satisfaction of the criterion of learning seems to have shifted from the second to the *fourth response of each trial. During learning the second response* was wrong in 94.7% of the trials (see Table 4), and after learning it was wrong in only 34% of the trials. (This latter percentage is calculated from data in Table 6.) The *fourth response was wrong*

TABLE 6

PERCENTAGE OF TRIALS IN WHICH THE 16 POSSIBLE SERIES OF RESPONSES OCCURRED DURING AND AFTER LEARNING

16 possible series of responses	Bones During L (80)*	Bones After L (20)	Sis During L (315)	Sis After L (185)
R R R R	3.8		6	6.5
R R R L			6	6.5
R R L R	2.5		6	24.9
R R L L	1.3	100.0	2.5	28.1
R L R R	2.5		6	
R L R L	3.8		2.5	
R L L R	21.3		22.5	5.9
R L L L	63.8		53.7	28.1
L R R R			.3	
L R R L				
L R L R				
L R L L			3	
L L R R			6	
L L R L			.6	
L L L R			4.4	
L L L L	1.3		9.8	

*Numbers in parenthesis indicate number of trials.

in only 29.6% of the trials during learning, whereas it was wrong in 37.3% of the trials after learning. What Sis seems to have learned was to respond *R R L* and the fourth response remained undecided. This fact is further shown in Table 6 which records for each subject the percentage of trials in which each of the 16 possible series of responses were made during and after learning. An examination of this table will reveal the fact that Sis made only six different series of responses following learning, and that in most of these at least the first three responses were correct. During the last 50 trials of this period there appeared only three different series of responses, *R R L L, R R L R,* and *R L L L,* which occurred 18, 19, and 11 times, respectively In other words, during her last 50 trials, Sis responded *R R L* 39 times, and *R L L* only 11 times. In the same 50 trials the fourth response was *R* 21 times, and *L* 29 times The reason that Sis's difficulty shifted to response four following learning is uncertain. Preceding learning the responses for both subjects were learned in the order 1-3-4-2 At the time work with Sis discontinued responses were being fixed with her in the order 1-3-2-4. In both of these arrangements it will be noted that the odd-numbered responses gave less difficulty than did the even-numbered responses.

Altogether in the 650 trials of all three monkeys the only series of responses to be made more often than would be expected by chance are *R R L R, R R L L, R L L R,* and *R L L L* It will be noted that in all of these series the first and third responses are correct Series *L R R L* and *L R L R* never occurred, and series *L R L L* and *L R R R* occurred only once and twice respectively. In all of these latter series the first response is wrong The relative order of difficulty of the four responses in the series *R R L L* appears to be, from easiest to most difficult, 1-3-4-2, under the conditions in the present experiment

2. *Controls.* After Bones demonstrated mastery of the problem, certain tests were undertaken to determine whether his double alternation of responses depended upon cues he might be receiving from the operation of the apparatus The only possible source of external cues appeared to lie in the operation of the doors of the maze, since nothing else was changed throughout each trial. To test this possibility the following controls were introduced:

(1) The side doors were open throughout the entire trial.
(2) The front doors were open throughout the entire trial
(3) All four doors were open throughout the entire trial

Control 1 was introduced after Bones had run six correct trials in succession Bones's responses were all correct during the trial in which the first control was introduced. This indicated that the operation of the side doors played no essential part in determining the double alternation of response by this subject. After three additional practice trials, all of which were correct, Control 2 was introduced. Bones would not work on this day, but his two responses were *R L* There was some question whether the second response was *L* because of his lack of hunger and refusal to work, or because the front doors were open and he was disturbed.[2] Sis, however, had also refused to work on this day. I took the animals for a short walk through the laboratory, and then returned to the experimental room for another pair of trials Sis refused to work in her second time in the maze, and Bones went *R* but did not come to *F*. It therefore seemed likely that Bones had not been disturbed by the operation of the front doors, but rather by his lack of hunger The point remained in question, however, until the second control was tried again after three more correct practice trials. This time the responses were all correct under the conditions of Control 2 Thus it appeared that Bones was not dependent upon the operation of either the side or the front doors in order to perform correctly double alternation.

As a final check upon this point, Bones was given three more practice trials, all of which were correct, and was then tested under the conditions of Control 3, in which all the maze doors were open throughout the entire trial. During this trial, so far as I could detect, there were no sounds except those made by Bones himself. He ran without hesitation at his usual slow steady gait *R R L L*. During this trial I leaned forward in such a way that I was not in the subject's view, even if he could have received visual stimulation through the mirrors from the experimenter's portion of the room. I watched his responses through the observation hole and noted that he did not even glance in my general direction while in the center alley. Altogether this made Bones's eighteenth correct trial in suc-

[2]It may be noted that in Controls 2 and 3 a new element is introduced into the temporal maze situation. This consists in a new bifurcation of the pathway when the front doors of the maze are left open throughout a trial In practice this situation caused no difficulty in that the subjects went up the central alley upon leaving either front section, even though they could have gone into the opposite front section of the maze.

cession. His performance of two more correct trials following the introduction of the shock grids has been described above.

The fact that Bones's double alternation of responses was in no way affected in these controls indicates that he was not dependent upon external cues in order to perform the problem correctly. A further evidence of this point is the fact that he could miss 10 days work (during the introduction of the shock grids), and still perform the problem correctly in spite of the distraction inherent in the new feature of the apparatus encountered at that time There can be little doubt that Bones had mastered the double alternation problem, *R R L L*.

3. *Extension of Series* Neither subject was tested on a trial containing more than four responses during this experiment This proved impossible with Bones because of his habit of not completing his fourth response regularly, and because of the fact that the introduction of shock did not secure continuous walking with him On his eighth correct trial, after he had finished his four regular responses, Bones opened the left front door before the wire door in the center alley was down He then went up the center alley to *x*, and responded *R* (correct) This series of five responses was accidental, but proved to be the only extension of responses in the entire experiment, and was consistent with double alternation. On three occasions following groups of six and five correct successive runs I had planned to extend trials with Ss to eight responses On each of these occasions an error appeared in the first four responses, and for this reason the trials were not extended Thus the question of whether the monkeys could extend the double alternation of responses from four to eight responses remained unanswered.

4. *Comparison of Monkeys and Raccoons* A comparison of the monkeys' performance in the temporal maze with that of Hunter's raccoons (5) may be made only indirectly This is due largely to the fact that the raccoons were trained for about 120 days on eight responses per day before beginning work on the four-response problem Presumably the four-response series is easier than the eight-response series, but two trials of four responses each are probably not equal to one trial of eight responses These points should be kept in mind while considering the following comparisons Table 7 presents a comparison of the raccoons and monkeys in terms of the number of correct responses in each successive group of 40 responses Column 1 gives an average for the four raccoons calcu-

TABLE 7
NUMBER CORRECT IN EACH SUCCESSIVE GROUP OF 40 RESPONSES*

Average for raccoons	Best record of any raccoon	Monkeys Bones	Sis
17	21	23	17
17	18	27	17
19	23	26	18
22	24	25	19
20	26	25	22
16	22	28	22
18	23	30	23
20	22	29	25
20	21	40	28
	21 of 32	40	27

*Each group consisted of 5 trials for the raccoons and 10 trials for the monkeys

lated from Hunter's Table 1 (5, p. 381). Column 2 gives the best record of any raccoon for each successive group of 40 responses. The records of Bones and Sis for a like number of responses are given in columns 3 and 4 respectively. The superiority of the performance of the monkeys is clearly indicated. Two of the raccoons made groups of four correct responses in two and three trials, but these trials were not successive. Bones's record of 20 successive correct trials is far superior to this, but Sis made only one perfect run during this time.

TABLE 8
NUMBER CORRECT IN EACH SUCCESSIVE GROUP OF 20 RESPONSES

Henri (raccoon)	Sis (monkey)
14	12
9	13
16	15
14	13
16	14
13	15
19	15
13	15
*18	14
4 of 4	3 of 4
In groups of 40 responses	In groups of 40 responses
27	31
24	32
25	*32
26	33

Table 8 presents a comparison of the work of the raccoon, Henri, on trials of four responses each, and of Sis for an equivalent period. Henri was selected because his performance was the best among the raccoons. His record is taken from Hunter's Table 4 (5, p 385). Preceding the trials described in these records, Henri had been given 121 trials of eight responses each and Sis had had 242 trials of four responses It should be borne in mind, however, that the effect of the first 104 trials for Sis was apparently lost after the introduction of the shock grids. At first glance the upper group of records indicates for Henri a performance better than that of Sis On the average, however, their records are about the same In the lower group, Sis's records are consistently better than those for Henri One reason for Sis's record showing a rather consistent 75% accuracy score is that these trials just preceded her learning and her typical series of responses was *R L L L* The asterisks mark the group of responses during which each animal met the criterion of learning. From this point Sis's record continued to improve, while work with Henri was discontinued. In terms of groups of correct successive trials Sis was definitely superior to the raccoons.

Summary and Conclusions

In the present experiment three young rhesus monkeys were trained in the same double alternation temporal maze used by Hunter with raccoons. During learning the subjects passed through three stages, which were · (*a*) a "random" stage, marked by many extra moves through the maze; (*b*) a stage of regular running, in which the typical series of responses was *R L L R* on each trial, and (*c*) a stage of hesitation prior to certain of the responses These same types of behavior and these same general stages also appeared with human subjects in the second experiment of this series. One monkey learned the problem *R R L L* in 80 trials and performed it correctly for 20 successive trials A second monkey learned the problem in 315 trials, and performed numerous groups of from two to six correct successive trials throughout the 185 trials that she was given following learning. An analysis of the relative difficulty of the four responses of each trial for these subjects shows that during learning the odd-numbered responses tended to be easy and the even-numbered responses tended to be difficult The responses in the series *R R L L* were learned in the order 1-3-4-2 by both subjects during learning Following learning the difficulty for the monkey who took 315 trials

to learn shifted from the second to the fourth response of each trial. After learning, this subject responded *R R L* during most of her trials, and the fourth response remained unfixed, but tended to be correct

Controls were introduced with the subject who learned the problem in 80 trials to determine if he were responding to cues received from the operation of the apparatus With all doors of the apparatus open throughout a trial and with no movement or sound in the apparatus, this subject was able to perform the problem without hesitation or error

In the present experiment it did not prove possible to test any of the subjects on the extension of the double alternation of responses to series of responses of greater length than those upon which the subjects were trained Shock grids were introduced into the maze and during part of the experiment punishment (electric shock) was used instead of hunger to secure movement through the maze This proved to be unsuccessful with one subject and very successful with another. In general, the monkeys did not seem to be well adapted to maze work in that their natural response when hungry was not continuous locomotion, as is the case with rats and raccoons. This fact led to the development of a new apparatus for testing double alternation behavior. A description of this alternation box-apparatus will appear in the third paper of this series.

Data are presented which make possible a comparison of the performance in the temporal maze of monkeys and raccoons. The monkeys demonstrated ability in the double alternation problem superior to that found for raccoons This is consistent with the results of Tinklepaugh (7), who found that the monkey is superior to the raccoon in the delayed reaction problem

In response to the questions which this experiment sought to answer, the following conclusions may be stated:

1 Monkeys can learn the double alternation of four responses, *R R L L*, in the temporal maze, and in its performance they are not dependent upon external cues The performance of monkeys in this experiment is superior to that thus far demonstrated for rats and raccoons in the double alternation temporal maze

2 Under the conditions of the present experiment it was not possible to determine whether monkeys can extend the double alternation of responses to series of greater length than those upon which they were trained The monkeys used in this experiment did not prove well adapted to maze work

The former of these conclusions supports the symbolic process hypothesis advanced by Hunter (5) to explain the performance of double alternation in the temporal maze It affords additional evidence that the double alternation temporal maze may be placed with the delayed reaction experiment as another method of demonstrating the presence of symbolic processes in human and infra-human subjects

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LE PROBLÈME DE L'ALTERNATION DOUBLE
I LE COMPORTEMENT DES SINGES DANS UN LABYRINTHE TEMPOREL, À ALTERNATION DOUBLE

(Résumé)

Cet article rapporte la première d'une série d'expériences qui ont comme but une analyse plus etendue de l'alternation double dans ses rapports avec les processus symboliques qui emploient les singes et les sujets humains On a entraîné trois singes rhésus avec une epreuve par jour dans le même labyrinthe temporel employé par Hunter avec les ratons Pendant l'apprentissage les sujets ont passé par trois étapes, lesquelles ont eté (1) une étape "au hasard", caractérisee par des mouvements supplementaires dans le labyrinthe; (2) une étape de parcours ordinaire, caractérisée par le comportement d'alternation simple, et (3) une étape d'hesitation antérieure à certaines des réponses Les singes ont appris le problème, *D D G G*, dans 80 et 315 épreuves L'analyse de la difficulté relative des quatre reponses de chaque épreuve montre que pendant l'apprentissage les reponses impaires ont tendu à être faciles, et les réponses paires ont tendu à être difficiles Les contrôles ont montré que le singe dans sa double alternation de réponses n'a pas dépendu des suggestions reçues de l'opération de l'appareil Ainsi

on a trouvé que les singes sont supérieurs aux rats et aux ratons dans le labyrinthe temporel, à alternation double. Tinklepaugh a trouvé la même habileté relative chez les singes dans l'expérience de la réaction remise Les résultats de cette expérience, le sujet de cet article, soutiennent la position adoptée par Hunter sur la relation du problème de l'alternation double et l'expérience de la réaction remise, et l'explication de l'exécution du premier problème en terms des processus symboliques.

GELLERMANN

DAS PROBLEM DER DOPPELTEN ALTERNATIVE I DAS BETRAGEN VON AFFEN IN EINEM ZEITLABYRINTH ('TEMPORAL MAZE') MIT DOPPELTER WECHSELFOLGE ('DOUBLE ALTERNATION')

(Referat)

Man erstattet hier Bericht uber die erste einer Serie von Untersuchungen in denen eine weitere Analyse der doppelten Wechselfolge in Bezug auf symbolische Vorgange an Affen und an menschlichen Versuchspersonen *unternommen wurde Es wurden drei Rhesus Affen dressiert, mit einer* Probe per Tag, in demselben Labyrinth das Hunter fur Waschbaren ('raccoons') gebrauchte Wahrend des Lernens machten die Vpn drei Stadien durch, namentlich: 1) ein Stadium des Geratewohl ('a random stage') durch uberflussige Bewegungen durch das Labyrinth karakterisiert, 2) ein Stadium des regelmassigen Laufens, durch einfaches Abwechslungsbetragen ('alternation behavior') karakterisiert, und 3) ein Stadium des Zögerns ('hesitation') vor einigen gewissen Reaktionen Die Affen erlernten das Problem *R R L L* in 80 und 315 Proben Eine Analyse der relativen Schwierigkeit der vier Reaktionen jeder Probe zeigt, dass, wahrend des Lernens, die mit ungeraden Zahlen nummerotierten Proben die Richtung hatten, leicht zu sein, wahrend die mit geraden Zahlen nummerotierten die entgegengesetzte Richtung erwiesen Kontrollproben haben erwiesen, dass sich der Affe in seinen Reaktionen mit doppelter Wechselfolge nicht auf Weisungen verliess, die er durch das Wirken des Apperats erhielt Die Affen erwiesen sich also in dem Zeitlabyrinth mit doppelter Wechselfolge als Ratten und Waschbaren uberlegen Tinkelpaugh hat bei Affen im Experiment mit verspateter Reaktion ('delayed reaction') eine ahnliche relative Tuchtigkeit gefunden Die Ergebnisse des hiesigen Experiments bestatigen den Stand Hunter's uber das Verhaltniss der Problems der doppelten Wechselfolge zum Experiment mit verspateter Reaktion, und zur Erklarung des Betragens innerhalbe des letzteren in seinem Zusammenhang mit symbolischen Vorgängen ('symbolic processes')

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THE RELATIVE EFFICACY OF FORM AND BACKGROUND IN A CHILD'S DISCRIMINATION OF VISUAL PATTERNS*[1]

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NORMAN L MUNN AND BERYL RAE STIENING

INTRODUCTION

The problems investigated in this experiment were suggested by Hunter's (7) paper concerning the contribution of the background to the discrimination of visual patterns He claimed that the animal tested in the usual discrimination apparatus "is confronted *not* by two *'forms'* corresponding to the configurations of the opal glass, but . . what the animal sees is a triangle or a circle each in more or less of a square setting. Now I put this question," he continues, "If an animal is trained on diagrams 1 and 2 (a triangle on its base presented in a square background and a circle in a similar background), is it any wonder that he breaks down when confronted by diagrams 2 and 3 (the triangle is inverted in diagram 3)? The problem would be puzzling to a human adult, unless he had been *told* to attend to triangularity!" (7, p. 331) These comments by Hunter were directed at an experiment of Bingham's. Bingham (1) trained his chick to discriminate a triangle from a circle After this the inversion of the triangle led to a loss of the power to discriminate. Bingham (2), in another paper, objected to Hunter's interpretation of the experimental set-up Bingham claimed that the forms did not appear in rectangular backgrounds, but were surrounded by a halo of light, the rest of the pattern being dark He also suggested that "shape" and not "form" discrimination was obtained in his experiments. By "shape" he meant a differential distribution of light. He says, "It is not to be denied that a triangle with vertex up differs from a triangle with vertex down But we can scarcely say that they are two different *forms* They are both

*Accepted for publication by Walter S Hunter of the Editorial Board and received in the Editorial Office, June 13, 1930

[1]The authors are indebted to Mrs J O'Connor who allowed them to use her child for this investigation They are also indebted to Prof. F H Stiening for the drawings

triangles, yes, more than that, they are equilateral triangles. Where they differ is *not in form but in shape.* When the extended base of the triangle is so placed as to stimulate the region of the retina which was formerly stimulated by the vertex of the triangle, a condition occurs similar to that pointed out regarding Lashley's 'forms': the forms remain identical, but the lines of maximum and minimum extension have interchanged This fact led me to conclude . . . that *the apparent reactions to forms are the result of keen perception of size differences* I might have said they are due to perception of shape differences. . Not 'the perception of form,' therefore, but the perception of shape 'is based precisely on the unequal stimulation of different parts of the retina'" (2, p. 140) Miss Washburn (14) claimed that no animal could discriminate form in Bingham's sense unless it possessed a capacity for forming abstract ideas.

Coburn (4) and Watson (5) have obtained discriminative behavior which was not disturbed by an inversion of the positive stimulus, a triangle. These results, however, since the experimenters did not determine the efficacy of the *"negative"* stimulus, cannot be accepted as evidence of form discrimination in Bingham's sense. Weidensall (16) and, recently, Munn (10) have shown that the *"positive"* stimulus may be entirely uneffective Munn (10) has been able to demonstrate good discrimination of "shape" (in Bingham's sense) in the chicken He could find no evidence, however, of a discrimination of form *per se.* His results are therefore in conformity with those of Bingham.

The present experiment concerns two problems (*a*) Does the shape of the background on which a form appears contribute anything essential to the accuracy of discrimination? This problem, it appears to the writers, is of paramount importance to the methodological assumptions of the Gestalt psychologists, as well as to the technique of animal experimentation in the field of vision. (*b*) Is it possible to obtain in a young child the discrimination of form *per se* that could not be demonstrated in the chicken

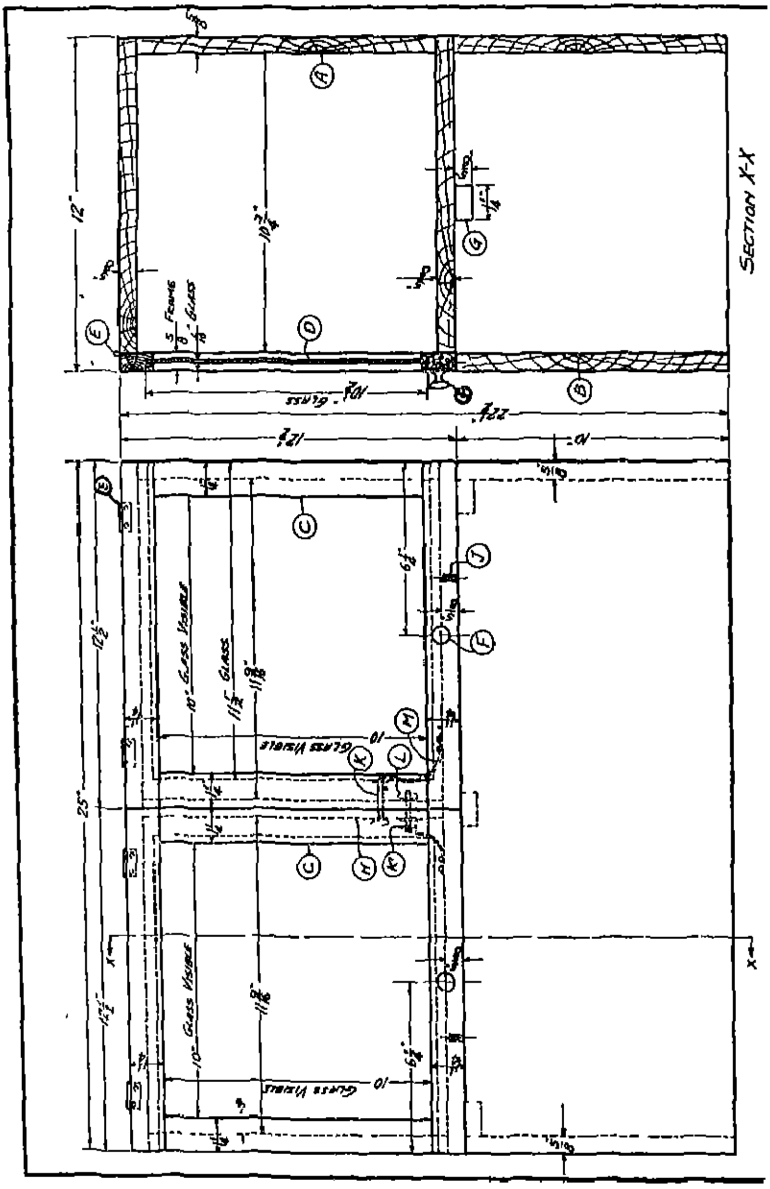
A number of experiments have been conducted to discover the efficacy of color, form, and certain types of abstraction in the discriminations of children (3, 5, 6, 8, 9, 11, 12), but they have little bearing upon the present problem. Most of them involve the preferences of children of different ages for color or form Our experiment did not involve preference The subject was trained under conditions comparable to those used in animal discrimination experiments

Volkelt (13) has made the statement that perception for the child is in terms of *wholes* from which, in the growth process, the so-called "parts" are discriminated relatively slowly Other than this, we could find no references in the literature which seemed to bear directly upon our problem Wever (17) has summarized the literature pertaining to figure and ground in human perception of form, but these studies have been phenomenological instead of objective in nature.

Apparatus and Method

An apparatus, in order to satisfy the requirements for such an investigation as the one suggested above, should have the following characteristics: (*a*) It should offer the possibility of presenting two configurations toward which the child might make an objectively measurable differential response. (*b*) It should offer the possibility of rewarding the subject after a correct response and of punishing it after an incorrect response, or a combination of the two (*c*) It should offer the possibility of an independent control of the form stimuli and the backgrounds upon which they appear. (*d*) It should make possible a control of all cues extraneous to those coming from the forms or patterns

The apparatus which we used in this experiment satisfied all of these requirements It consisted of a box with two doors of equal size which were hinged at the top so that the child, by means of a small knob, could raise either of them The configurations to be discriminated appeared on these doors When the child raised the correct door he was rewarded by finding a piece of chocolate immediately behind it. If he made an incorrect response he was prevented from obtaining any chocolate until the next trial This delay acted, in a sense, as a punishing factor. It was possible to change the background upon which a form appeared without in any way changing the form itself One could also make any changes in the form without changing the background upon which it appeared The configurations could be changed from side to side in the apparatus in a chance order so that the subject could not respond to their relative position All factors such as olfaction, audition, etc, could be prevented from contributing to the discrimination These controls will be described later For the use of others who may wish to duplicate the present apparatus the following detailed specifications are presented.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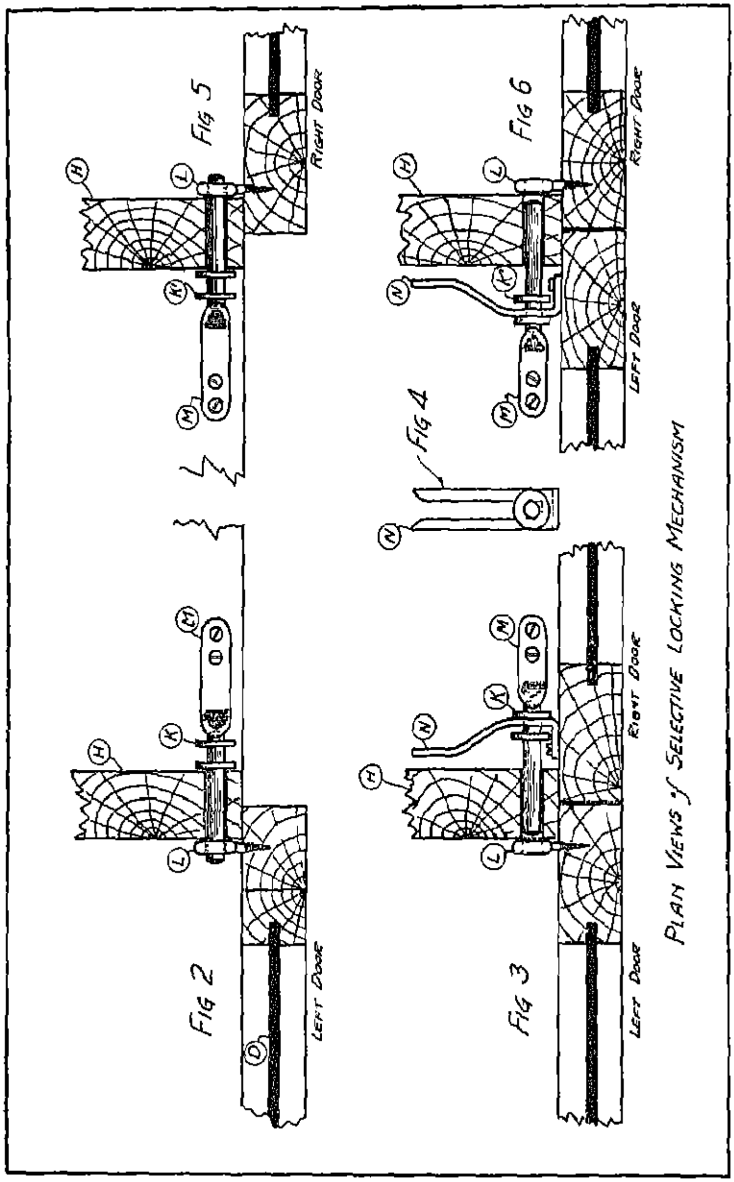

FIGURES 2-6
PLAN VIEW OF SELECTIVE LOCKING MECHANISM

Specifications

The apparatus is diagrammatically presented in Figures 1-6. It consists essentially of an upper compartment and a lower compartment, both constructed of wood. The lower compartment, *B*, is provided merely to elevate the stimuli to a convenient height from the floor. It may be varied in height to accord with the heights of various subjects. It was lower than the line of vision because the child was required to take the door by the knob and, by reaching upward, to push it open. If it had been higher he could not have reached high enough. The top compartment, *A*, which is detachable from the lower one, is held in position by means of four wooden blocks, *G*, fastened rigidly to *B*. This top compartment is divided into two parts of equal dimensions. Each of these divisions is covered by a door, *C*, hinged at the top by means of two hinges, *I*. Each door is grooved, as shown in Figure 1, to permit retaining of a sheet of opal flash glass, *D*, such that the entire opening is covered by the glass. After the glass is inserted into the frame we have a uniform white area in each door. This area is 10 x 10 inches. We used glass because it reflected light well and because it could readily be cleaned.

The right-hand frame of the right door and the left-hand frame of the right door have slots extending completely through them to permit entrance and retention of the opal flash glass. Each door was provided with a ball-bearing spring arrangement to be described presently. There was a knob, *F*, at the bottom of each door.

The two divisions of the top compartment were divided by means of a panel, *H*, to which a selective locking device was fastened. This device consisted of two brass plungers, *K* and *K'*, which pass through holes in the wooden panel, *H*, the center of the hole in the eye-screw, *L*, coming in alignment with the center of the hole through which the plunger moves. At the back of each plunger was a steel spring, *M*, so arranged as to apply pressure to the plunger and push it through the eye-screw until arrested by the brass collar. Figure 1 shows two possible positions of the plunger. When both doors are closed both plungers are in the same position, i.e., withdrawn from the eye-screws. As soon as one door is opened, however, a plunger shoots through to the other door and automatically locks it. This device is further illustrated in Figures 2-6. Each door, it will be seen, is provided with a brass cam-shaped finger, *N* (Figure 4), which straddles the plunger and is so arranged that when the door is being closed the finger will pass between the collars shown on the plunger, *K*. The cam shape of this finger is such that as the door is further closed the movement of the finger between the collars will act against the spring, *M*, and thus withdraw the plunger from the eye-screw. When the right-hand door has been opened the left-hand door is locked as illustrated in Figure 2. When the left door has been opened the right-hand door, represented in Figure 5,

is similarly locked When both doors are closed simultaneously the locking device is as illustrated in Figures 3 and 6

Each door is snapped securely in place by means of a ball-bearing spring latch (*J* in Figure 1) which engages with the plates fastened to the lower compartment, *B* This is to insure that the eye-screw will always be in alignment with the hole through which the plunger works

The entire apparatus was given a double coat of black lacquer in order to secure an even finish

In Figure 7 are represented the configurations which were, from time to time, presented in the 10 x 10-inch openings of the doors of the upper compartment of the apparatus The pieces of opal flash glass which slid into the grooves in the doors were 11½ x 10½ inches. Two pieces of black ticket cardboard were cut to the same dimensions as the opal flash glass so that both could be slid into the doors together In order to obtain the white backgrounds upon which the forms appeared, we merely cut an opening of the desired shape in the black cardboard. The forms which appeared in the centers of the white backgrounds were cut from the same black cardboard and glued to the center of the glass. The area of the white surfaces onto which we glued the forms was 36 inches.

The subject was a healthy, seemingly intelligent, male child of 15 months of age at the beginning of the experiments. He was permitted to examine the apparatus without restriction, and a small piece of chocolate was found in each compartment. During this preliminary procedure the patterns were not exposed.

We then exposed the patterns to be discriminated. The apparatus was placed in a fixed position so that both stimulus patterns were equally illuminated by a light placed about 6 feet above the apparatus and slightly in front of it Dark blinds shut out illumination that could not be controlled From the playroom in which the apparatus was placed a narrow hallway led to another room While the patterns were being changed in position according to a chance order the child was playing hide-and-seek in the other room. As soon as the apparatus was ready and a piece of candy and a bright colored ball had been placed in the correct compartment, the child was brought from his "hiding place" (he was made to think that he was playing a game in which he was to hide so that the experimenter could not find him) along the hallway to the entrance of the experimental room The experimenter said to the child, "Go and get choc," and the child pushed the door open and entered the room,

making his discrimination while the experimenter remained outside of the room at the doorway Upon opening the door of the room the child was confronted by the apparatus and had merely to go straight towards it.

To control the possibility of olfactory cues candy was sometimes placed in both compartments. A piece of candy was kept in both compartments while the apparatus was not in use Since the visual stimuli were of equal area and brightness, these factors were adequately controlled The chance series of presentation was made up every day just preceding the experiment. Particular care was taken to see that the child could not discriminate on the basis of a position habit. Although the experimenter was at the doorway of the room while the child was making a discrimination, and the child very seldom looked back at the experimenter, we had a strange person who did not know the nature of the problem run the subject for a number of trials at crucial points in the experiment Care was taken to see that there was no difference in time between the trials in which the series called for a change in position of the stimuli and the trials in which the stimuli were not changed in position. Other controls consisted in changing the glass and in the introduction of the same forms cut from fresh cardboard. These controls effectively eliminated the possibility that extraneous cues were influencing the discrimination.

Ten trials were given daily, and a record of the correct responses and the time elapsing between the opening of the door of the experimental room and the door of the apparatus was kept The time record was not of much use, since it varied greatly even during the training series. We thought, however, that it might be used as an indicator of disturbance when we came to our controls We obtained good cooperation from the child throughout the experiment No instructions other than "Go and get the choc" were given at any time Between each day's trials the apparatus was locked in a closet so that the child could have no contact with it except while the experiment was in progress We adhered to this method throughout the entire investigation.

Experiment I

In this experiment we wished to discover whether a discrimination between such patterns as those presented in Figure 7, Combination 1, would disintegrate when the backgrounds upon which the forms appeared were changed in form We also wished to determine whether,

after a discrimination had been obtained, the accuracy of discrimination would be affected by changes in the relationship existing between the patterns or forms, i e., by changes of the negative stimulus, by inversion, etc.

The backgrounds upon which the forms appeared were composed of elements of equal area and brightness The white backgrounds were 36 square inches in area The inner black forms were both 2 square inches in area

During the first 100 trials of this experiment candy was the only reward. After the 100th trial we added a bright colored ball. The locking device was also introduced at this point because we found that the candy was too easily obtained after an incorrect response The child merely had to try the other door after making an incorrect response Under the new conditions he did not get any candy except when the response was initially correct

The results of this experiment are presented in Tables 1 and 2

TABLE 1

POSITIVE STIMULUS A CROSS ON A WHITE DIAMOND BACKGROUND, NEGATIVE STIMULUS A SQUARE ON A SIMILAR BACKGROUND
(See Figure 7, Combination 1)

Trials	% correct in 50 trials	Remarks
50	42	
100	30	
150	52	Locking device first used.
200	72	
250	58	Subject ill
300	72	
350	82	Locking device discontinued.
400	100	

(A learning curve was constructed from these data but since it is of the conventional type its presentation here seems unnecessary.) The discrimination, when finally mastered, was maintained with a high degree of consistency When the locking device was introduced the child soon became so conditioned that he never, after an incorrect response, attempted to open the other door We then discontinued the use of the locking device. The controls now to be described are presented in Combinations 2-11, inclusive, of Figure 7 The results are presented in tabular form in Table 2. The following are the controls and results.

1 The cross was turned 45° to see whether its position in the

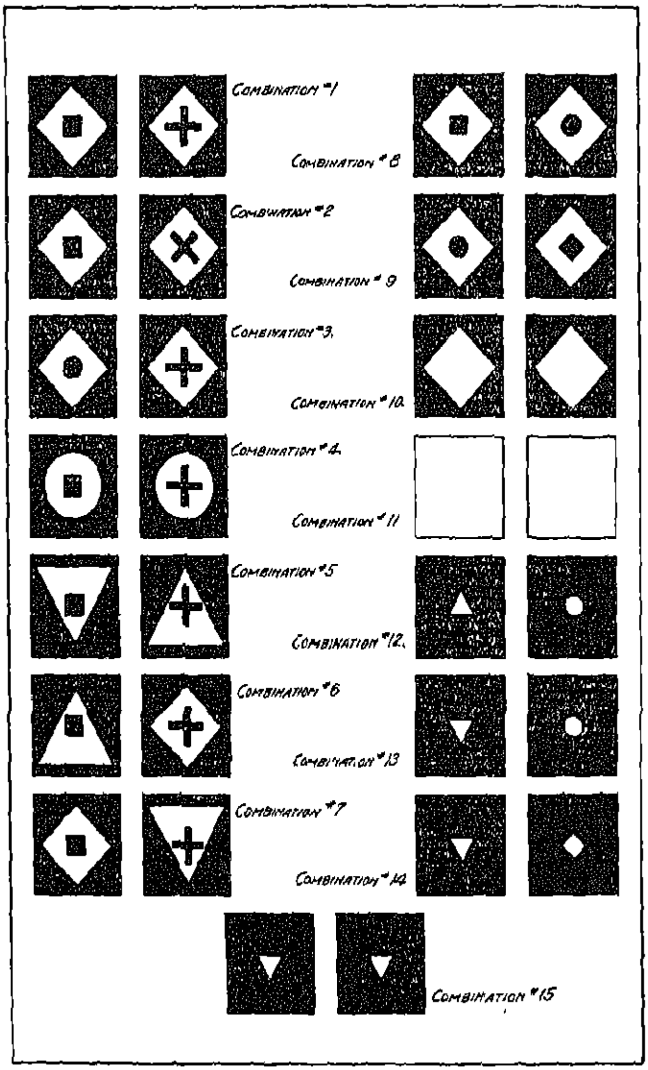

FIGURE 7

The Combinations of Stimuli Which Were Presented in the Doors of the Apparatus

In the first column the right-hand forms are positive This is true of Combinations 8-11 The left-hand figures are positive from Combinations 12-15

TABLE 2
CONTROLS USED IN EXPERIMENT 1

Stimulus combination (Figure 7)	No of trials	% correct
1	last 50	100
2	10	100
3	14	93
4	10	100
5	10	100
6	10	100
7	10	100
8	10	90
9	12	83
1 (positive and negative reversed)	12	58
10	10	40
11	10	30

total configuration had anything to do with the accuracy of discrimination (2, Figure 7) It will be seen from Table 2 that the accuracy of response during this control was 100% in 10 trials

2 The square (negative form) was changed to a circle of equal area and brightness (3, Figure 7). If the subject had been reacting to the negative pattern and not to the cross, he should now have broken down If the response were to a cross-versus-a-square, the new situation, cross-versus-a-circle, might be disconcerting Out of 14 trials, however, he made but one incorrect response. This error occurred as follows: Until the fourth trial he apparently did not respond to the circle On the fifth trial he stopped suddenly, looked at it, and opened the door on which it appeared. After this he did not again attempt to open the door on which it appeared.

3. The diamond-shaped backgrounds were now changed to circular ones of equal area and brightness (4, Figure 7) The cross was still the positive stimulus and the square the negative one The child's responses were all correct in 10 trials, and the time interval between opening the door of the room and opening the door of the apparatus was no longer than usual

4. The backgrounds were again changed, this time differing from each other (5, Figure 7) The backgrounds were triangular and differed from each other with respect to the positions of their apices In one trial the cross would appear on one background and in the next trial on the other background according to the series of presentation In 10 trials all of the responses were correct, and the time for making the response was no longer than in the training series.

5. The backgrounds were again changed (6 and 7, Figure 7). The results for 10 trials were still unaffected by the change. It seemed apparent from the controls so far carried out that the child was reacting to the cross, as such, and not to the total configuration of the stimulus on one door nor to the relationship existing between the forms We now wished to discover what the child would do when we eliminated the cross and substituted a new form

6 The cross was now changed to a circle of equal area and brightness (8, Figure 7). This, in its diamond background, was considered the positive stimulus. Exposed to this combination, the subject hesitated, closely examined both doors, and apparently reacted to the square in a negative fashion, for he responded with an accuracy of 90% in 10 trials.

7. We now attempted to make the total situation differ to a greater extent by using as the positive stimulus, a diamond, the square turned through 45°, in a diamond background As negative stimulus we used a circle in a diamond background (9, Figure 7) The subject responded to the positive door the first time After that he made two errors. He then responded correctly for 9 trials in succession. Out of 12 trials, then, his accuracy of response was 83% Since the situation was almost entirely new, it seemed that he was either responding to extraneous cues or had been conditioned, in a remarkably short time, to the new combinations

8. The original combination (1, Figure 7) was now replaced. The relationship to reward, however, was reversed The candy and ball were now placed in the compartment covered by the configuration containing the square We wished to determine whether such a reversal of conditions would demonstrate any evidence of habit interference from the previous training series. If such were the case it would seem that the subject had indeed been responding positively to the cross and negatively to the square in our original set-up His responses were 58% correct in 12 trials He responded to the cross for the first 5 trials After this he made all of his responses to the square. In this situation, then, he was not as readily reconditioned as in the combination above (9, Figure 7). However, the fact that the child could so readily be conditioned was somewhat surprising We decided, therefore, to make a crucial test to see whether any extraneous cues were effective elements in the discrimination

9. In the first place, we removed the forms from the centers of the diamond backgrounds (10, Figure 7), thus offering two con-

figurations which *could not* be discriminated except on the basis of secondary cues The cardboard which had served to form the background of the positive configuration in the original series was still changed from side to side in a chance order, the chocolate and ball being placed behind it. The child only made 4 correct responses in 10 trials. In the second place, we removed the cardboard areas, thus leaving nothing but the opal flash glass (11, Figure 7). The candy and ball were placed behind the sheet of glass that was arbitrarily designated the "positive stimulus" Only three out of 10 trials were correct It is evident, therefore, that the child had been responding to the form aspect of the patterns and not to extraneous factors.

These results can be summarized as follows:

1 The positive stimulus (cross) was responded to with 45° rotation, with 5 changes in background, and with 5 different negative stimuli.

2 The negative stimulus was an effective element of the total situation only in Control 8 (8, Figure 7) where the positive stimulus was an entirely new one

3 When an entirely new situation was presented the child demonstrated that it could very readily adjust by making correct discriminations

4 Controls of various kinds unequivocally demonstrated that the child could respond to form *per se.* The subject responded to the form regardless of the retinal distribution of light emitted by it and regardless of the background upon which it appeared This would seem to be the only experimental significance of Washburn's "abstract idea" of form. She said, in reviewing Bingham's experiments with the chicks, "Bingham's chicks discriminated between a circle and a triangle when the apex of the triangle was on top, but since this discrimination broke down when the circle was presented with a triangle whose base was uppermost, the chick failing to choose the triangle, Bingham concludes that the chick was not reacting to form difference, but to 'the unequal stimulation of different parts of the retina' The reviewer would conclude rather that the chicks were not possessed of an abstract idea of triangularity A triangle with apex up is a different form from a triangle with apex down, the two have in common only the abstract quality of three-sidedness" (14, p 320).

Although we had fairly good evidence of a discrimination of form

per se,[3] we thought that it might be better to retrain the child on a problem involving the stimuli used in Bingham's experiment and thus obtain further evidence on this point This constitutes our second experiment.

Experiment II

The stimuli presented in this experiment were a triangle on its base and a circle of equal area and brightness, each located in the center of a square black background. Both the circle and the triangle were 4 square inches in area The triangle was the positive stimulus in this combination (12, Figure 7) The forms were now white instead of black The subject was unable at first to discriminate correctly. But he learned to do this within 30 trials. He was then given 30 further trials, all of which were correct.

The triangle was now inverted (13, Figure 7) in an effort to throw light upon the question raised by Washburn and Hunter. Hunter (7), it will be recalled, thought that such a change in conditions would be puzzling even to a human being unless he had been *told* to respond to triangularity. Our child, of course, was told nothing. (As a matter of fact, he could hardly speak himself.) The inversion of the triangle did not disturb the behavior which was 100% correct in 10 trials. After this a diamond of equal area and brightness was substituted for the negative stimulus (14, Figure 7) in an effort to determine whether or not the original negative stimulus was effective in controlling the discrimination Again the response was 100% correct in 10 trials Both stimuli were now made identical (15, Figure 7), and the reward was placed behind the piece of cardboard which had served as the positive stimulus in the training series. The responses were only 30% correct in 10 trials

Although these controls were those suggested by Bingham, Hunter, and Washburn, and the child had still discriminated, we did not yet have absolute evidence of a discrimination of triangularity *per se*. It is possible that the child became conditioned to the triangle on its apex while responding to the negative stimulus in Combination 13, Figure 7. (The positive stimulus might have represented a new

[3]The child, during the training period and thereafter, occasionally pointed at everyday objects in any way resembling a cross and responded by the word "choc" His mother reported this and both writers observed it at different times. He once pointed to a crucifix over his mother's bed and said, "choc" This was additional evidence of a conditioning to form *per se*

situation so that the child was thrown back onto a negative discrimination of the circle While discriminating thus for 10 trials he might have become conditioned positively to the new position of the triangle so that, when the negative form was changed, he continued discriminating the triangle on its apex) Although this was a rather remote possibility, we thought it advisable to control it So six weeks after the experiment had been completed, we retrained the subject on Combination 12, Figure 7 Thirty trials were necessary to recondition him to the triangle on its base After he had made 30 correct responses in succession we inverted the triangle and changed the negative stimulus at the same time (14, Figure 7). The child maintained his discrimination of the triangle with an accuracy of 100% in 10 trials *This series of evidence is indubitable proof of a response to triangularity per se.*

Conclusions

1 It was possible, by means of perfectly objective methods, to train a child to discriminate between a number of forms and patterns presented visually in a discrimination apparatus

2 It was found that the shape of the background on which the form appeared was not an effective part of the stimulating conditions The evidence shows that the child responded to a *part*, rather than to the *whole configuration* This does not conform to the statement of Volkelt (13) mentioned in our introduction Nor is it in conformity with the contention of the Gestalt psychologists to the effect that animals respond always to a total situation Our results do not support the contentions presented in Hunter's (7) paper, but they do indicate the necessity of controlling both the factors of figure and ground before detailed conclusions can be drawn In a paper to appear shortly (10) the same phenomenon in chicks is reported. Their discriminative behavior did not break down when the backgrounds upon which the forms appeared were changed in form

3. It is interesting to note that a change in the negative form (one control only) led to no significant drop in the accuracy of response Likewise a control of the positive form, so long as the negative one was unchanged, seemed not to disturb the child Thus the child responded *positively* to one form at one time, being unaffected by a change in the negative one, and responded *negatively* to the negative stimulus when the positive form was changed This type of response has never been observed in any other animal as far as the writers are

aware. The senior author (10) was unable to obtain such a response in chickens.

4. Unequivocal evidence of a response to triangularity, to form *per se*, was obtained. Miss Washburn says that such a response is due to "an abstract idea of triangularity." We have pointed out that all that can be meant by such a statement is that form is responded to regardless of its position in space and the background upon which it appears. Of course we have not exhausted the number of controls which might be carried out in this connection. An *equilateral* triangle was the only one used, whereas we might have used isosceles, scalene, and other types of triangles. Our triangle was only turned 180°, whereas it might have been turned at other angles. The triangle was always upright before the subject, whereas it might have been placed before him in a horizontally extended position, etc. A fruitful field for further research is thus open. It would be interesting, also, to repeat this experiment with other primates as subjects.

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L'EFFICACITÉ RELATIVE DE LA FORME ET DU FOND DANS LA DISCRIMINATION DES DESSINS VISUELS PAR UN ENFANT

(Résumé)

On a entraîné un enfant, âgé de 15 mois, au moyen d'un appareil de discrimination, à discriminer entre une croix noire et un carré de la même aire et de la même clarté, les deux présentés au centre d'un fond blanc, en forme de diamant Après que l'enfant avait appris à discriminer avec une exactitude de 100 pour cent, on a changé de plusiers façons la forme des fonds, on a substitué des formes nouvelles à la forme négative, on a renversé la forme positive, etc Aucun de ces contrôles n'a influé sur l'exactitude de la réponse Plusiers contrôles ont montré que l'enfant discriminait les formes et non les dessins qui comprenaient les fonds sur lesquels celles-là se trouvaient Après qu'on avait entraîné l'enfant à discriminer entre un triangle (stimulus positif) et un cercle de la même aire et de la même clarté, on a renversé le triangle L'exactitude de la réponse a été toujours de 100 pour cent. La substitution d'une forme nouvelle au stimulus négatif de la série de l'entraînement a aussi été sans effet Quand on a changé les deux stimuli en même temps de sorte qu'une réponse correcte ne pourrait se montrer que sur la base de la forme triangulaire, l'enfant a répondu avec une exactitude de 100 pour cent Dans toutes ces situations l'enfant a répondu à la forme *per se* Le fond sur lequel se montrait la forme n'a pas été un élément effectif de toutes les conditions de stimulation L'enfant n'a pas répondu à la *relation* entre les deux stimuli Il a fait la réponse en chaque cas à une *forme* sans égard à sa distribution spatiale

MUNN ET STIENING

DIE RELATIVE WIRKSAMKEIT VON FORM UND HINTERGRUND IN DER UNTERSCHEIDUNG VISUELLER GESTALTEN BEI EINEM KINDE

(Referat)

Ein Kind von 15 Monaten wurde an einem Unterscheidungsapparat (Discrimination apparatus) geschult in der Unterscheidung zwischen einem schwarzen Kreuz und einem Quadrat von demselben Flacheninhalt und derselben Helligkeit, beide in der Mitte eines weissen, rhombus-formigen Hintergrunds dargeboten Nachdem das Kind gelernt hatte, mit 100-pro-

zentiger Genauigkeit zu unterscheiden, wurde die Form der Hintergründe auf verschiedene Weisen geändert Es wurden für die negative Form neue Formen substituirt, die positive wurde umgekehrt, u s w. Keine dieser Kontrollen beeinflusste die Genauigkeit der Reaktion. Mehrere Kontrollen zeigten, dass das Kind die Formen unterschied, und nicht Gestalten in denen *die Hintergründe worauf sie erschienen mit einbegriffen waren.* Nachdem das Kind dressiert worden war, zwischen einem Dreieck (positiver Reiz) und einem Kreis von dem selben Flächeninhalt zu unterscheiden, wurde das Dreieck umgekehrt. Die Genauigkeit der Reaktion war noch immer 100% Die Substitution einer neuen Form für den negativen Reiz blieb ebenfalls ohne Erfolg Wenn beide Reize zu gleicher Zeit so geändert wurden, dass die richtige Reaktion nur auf Basis der Dreieckigkeit stattfinden konnte, regierte das Kind mit einer 100%igen Genauigkeit. In allen diesen Situationen regierte das Kind auf Form per se. Der Hintergrund, worauf die Form erschien war kein wirkungsvoller wesentlicher Bestandteil der gesammten reizbietenden Verhältnisse Das Kind reagierte nicht auf das *Verhältnis* zwischen den beiden Reizen In jedem Fall reagierte es auf eine *Form* ohne Bezug auf dessen räumliche Anordnung

MUNN UND STIENING

MENTAL AND PHYSICAL MEASUREMENTS OF A SET OF TWELVE-YEAR-OLD QUADRUPLETS*[1]

From the Psychological Laboratories of Stanford University

SHIRLEY L BRINTLE

THE PROBLEM

The purpose of this study is to place on record a large number of physical, psychological, and educational measurements of a set of quadruplets, four girls, aged twelve years. So far as the writer can learn, these are the first objective measurements of the kind that have been made of a set of quadruplets

At least three important psychological and biological problems are connected with this study

1 To determine, if possible, whether any two or more of the members of this set of quadruplets are of the "identical" type

Twins are known to be of two types, those developing from one egg, called duplicate or identical; and those developing from two eggs and called fraternal or non-identical. There seems to be a general agreement among biologists and embryologists that identical twins are very similar in mental characteristics as well as in form and features, and that they are always of the same sex; also that non-identical twins may be either of like sex or of opposite sex and need be no more alike than ordinary siblings.

2 To find the traits upon which random environmental influences have had the most effect.

As soon as we are reasonably sure that two or more of the quad-

*Accepted for publication by Lewis M Terman of the Editorial Board and received in the Editorial Office, June 11, 1930

[1]To all who have contributed to this article, whether by way of suggestions in matters of procedure or by more specific and direct assistance, I wish to express my sincere thanks I am deeply indebted to the Keys quadruplets and to Mr. and Mrs F M. Keys, their parents, for their permission and cooperation in making the study, to Professor J W Shepherd of the University of Oklahoma whose interest and persistence aided in collecting the data; and to Dr Leslie Spier who made the physical measurements Grateful acknowledgment is especially due Dr Barbara Burks Ramsperger of Stanford University for offering many valuable suggestions in the organization of the material Above all, however, I wish to acknowledge my indebtedness to Dr Lewis M Terman of Stanford University who directed the study and criticized the manuscript

ruplets are identical then it will be necessary to find the traits in which they differ and the traits in which they are alike If we *are able to find the traits in which they differ we may infer that the* causes of these differences are environmental.

3. To trace the development of the subjects in the light of nature and nurture hypotheses

Since in the study of twins the question of the relative influence of similar environment and of similar endowment is always a matter of controversy, it is thought that the evidence obtained from the study of a set of quadruplets might throw some light on the nature-nurture problem In the present study, as will be seen, it seems as if we have both identical and fraternal twins that have had very similar general environment. If their general environment is conceded to be nearly identical, then it may be possible, by comparing the educational and intellectual status of the group, to find some evidence as to the relative influence of nature and nurture upon mental development and achievement

The Subjects

The Keys quadruplets are all girls and were born at Hollis, Harmon County, Oklahoma, on June 4, 1915. At birth there were no *injuries. The order of birth was. Roberta, Mona, Mary, Leota* The mother had had no previous plural births, although there were four other children born prior to these The others were two boys and two girls aged 24, 22, 21, and 18 at the time of this study

The mother was 33 years of age at the time of the birth of the quadruplets She was born in Texas, and her own mother had but two children, a son and a daughter. There is no record of any plural births on the mother's side. The father of the quadruplets was born in Alabama and was 39 years of age at the time of their birth. He was one of twelve children, among whom was one pair of twins. The grandparents of the quadruplets were all white and were born in the United States

Up to the time of the measurements, the children had lived in Hollis, Oklahoma, a small country town, and were vigorous, healthy, well-developed specimens of twelve-year-olds. Three of the children expressed a preference for outdoor activities; Leota, the least developed, for reading.

Both parents were intelligent and cooperated in a friendly manner

Roberta Mona Mary Leota

PLATE 1

AGE SEVEN MONTHS

(Note the striking resemblance of Roberta and Mona at this age)

Leota Mary Mona Roberta

PLATE 2

AGE TWELVE YEARS

in the study. The girls had been under their immediate care since birth The father was owner of a hardware business in Hollis

When asked how one might know them apart (Roberta and Mona have almost identical features), Roberta said· "I have a freckle on the right side of my nose and Mona has a freckle on the right side of her chin" Leota is entirely different in features from any of the other three With her blue eyes and blond hair she would scarcely pass for the sister of the darker haired and brown-eyed girls. Mary also has very different features from any of the others; however, she bears noticeable resemblance to Roberta and Mona

The quadruplets entered the public school at Hollis at the age of 6 years and 3 months They were promoted a grade each year and always had the same teachers At the time of the measuring they were in the seventh grade The parents state that Leota has attended school the least number of days Our records for the last four years show the total number of days of school attendance for that period to be as follows: Leota 659, Mary 673½, Mona 674½, and Roberta 671½.

Health History

Birth weight·	Roberta 3½ lbs.		Mona 4½ lbs
	Mary 4 lbs		Leota 3 lbs

There were no injuries at birth. All were normal, healthy, breast-fed babies

Age 2—All of them had the whooping cough

Age 3—Leota had pneumonia and was very seriously ill for a period of about three weeks

Age 7—Mona and Roberta had tonsils removed.

Age 10—All of them had the measles

Age 11—All of them had the mumps.

Anthropometric Measurements

On December 15, 1927, the quadruplets were subjected to a series of 33 physical measurements Dr. Leslie Spier of the University of Oklahoma took the measurements as prescribed by the late Dr Bird T. Baldwin (1)[2], and in addition observations on their dentition were

[2]Dr Spier has attempted to follow Dr Baldwin's definitions of the measurements as given in his *Physical Growth of Children* and elsewhere, but being uncertain as to his method of finding sitting height and stem length, he has taken sitting height alone by measuring first from floor to apex of the subject's head and immediately following with that from floor to chair seat, subtracting the second from the first

TABLE 1

	Roberta	Mona	Mary	Leota
Order of birth	1st	2nd	3rd	4th
Weight at birth	3½ lbs.	4½ lbs	4 lbs.	3 lbs
Height				
Standing (cm)	151 4	155 9	151 4	145.7
Sitting (cm) (see above)	75.3	77 4	75 5	74.9
Length				
Span of arms (cm.)	149 2	150 5	148.6	143 0
Shoulder to elbow (cm.)				
Left	29 0	31 3	30 2	27.8
Right	28.8	30 7	31.8	27 3
Elbow to finger tip (cm)				
Left	40 3	40 9	40.2	38 0
Right	40 4	41 5	40 3	38 8
Leg to top of hips (cm)				
Left	95 6	97 0	93 0	89 4
Right	95 9	96 3	93.2	89 4
Face (mm.)	106	110	111	107
Width				
Shoulder (cm.)	31.5	32.2	32.3	31 0
Hips (cm.)	24 1	24 9	26.2	23 2
Face (mm)	114	111	112	113
Wrist (mm)				
Left	46	49	47	46
Right	47	48	49	46
Chest width (cm.)	22 3	22 3	25 2	22 2
Chest depth (cm)	16 7	17 9	16 4	15 6
Diameter				
Head (anterior-posterior) (mm)	183	182	187	178
Head (transverse) (mm.)	138	140	141	136
Head (height) (mm)	123	130	118	116
Circumference				
Head and hair (cm)	52 6	52.6	53 0	51 1
Chest (cm)	68.8	71 8	69 0	63 5
Hips (cm)	71.0	73 5	76 0	66 2
Wrist (mm.)				
Left	130	133	142	131
Right	135	135	141	130
Upper arm (mm.)				
Left	190	198	197	184
Right	190	198	196	182
Upper arm flexed (mm)				
Left	203	206	208	191
Right	202	207	204	189
Weight				
(with light indoor clothing and without shoes) (lbs)	81	89	96¾	73
Indices				
Sitting-standing	49 7	49.7	49 8	51 2
Cephalic	75.5	76 9	75 3	76 5
Chest	74 8	80.1	65 0	70 3
Growth of hair (axillae)	none	none	none	none

made All body measurements were taken over light indoor clothing and without shoes The instruments used were a standard set furnished by Alig and Baumgartel The physical measurements and Dr. Spier's observations are as given in Table 1

Erupted Teeth

Roberta·	*Full permanent dentition except third molars*
Mona·	Full permanent dentition, including upper left third molar only.
Mary	As Roberta.
Leota·	Permanent dentition alone, except third molars and upper left first bicuspid, the canines being erupted but below the occlusal plane. The upper teeth are all small, the lower teeth as small as normal deciduous teeth

Summary of Physical Data

These quadruplets are very much alike in general build and appearance despite the differences now to be cited Roberta and Mona are so nearly identical in build and physiognomy as to be well-nigh indistinguishable Mary resembles these two closely in general appearance, although she is broader and heavier These three have identical coloring, chestnut hair, brown eyes, and well-pigmented skins. Leota is distinctly smaller, although her general build resembles that of the others, and is different in having quite blond hair, blue eyes, and a fair skin The general configuration of the skull is the same in Roberta, Mona, and Leota Mary differs in that her skull is not so high and has its maximum transverse diameter proportionately lower than in the other three The hair of all four is much alike in form (straight), texture, and distribution, despite the fact that Leota is quite blond

The general physical development of three of the girls is quite similar, despite the differences in breadth and weight of Mary. The dental data show Mona to be slightly more precocious Leota has a smaller build and less advanced dental development. Leota was the smallest of the lot at birth (by weight) She is also the only one who has ever had a serious illness, when three years old she had a very serious attack of pneumonia which lasted three weeks. She is also sedentary in her habits in contrast with the others On the

other hand, Mona, who had the greatest weight at birth, is now eclipsed by Mary, who at birth stood second in rank.

Roberta and Mona are as nearly alike as identical twins usually are, Mary is hardly different from Roberta and Mona, while Leota is as different from the others as siblings ordinarily differ from one another.

Intelligence and Achievement Tests

Three intelligence tests were given to the quadruplets: The Otis Self-Administering Test of Mental Ability, Intermediate Examina-

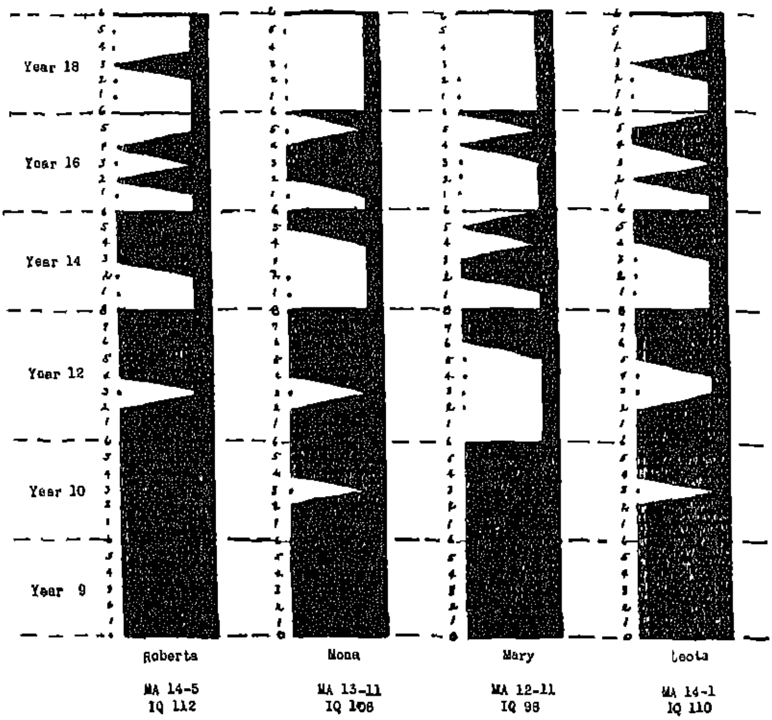

FIGURE 1
Profile Chart from Scores on the Stanford Revision of the Binet-Simon Tests
Chronological age 12 years 10 months

Note Shaded portions represent the correct answers. Dots indicate the incorrect answers.

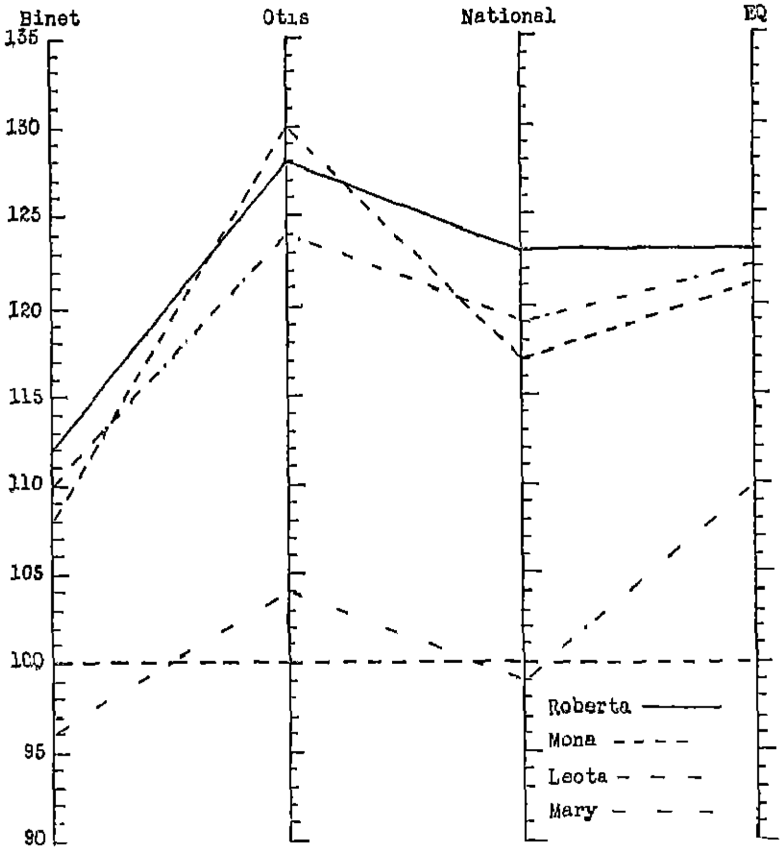

FIGURE 2
PROFILE SHOWING IQ'S FROM THREE INTELLIGENCE TESTS AND EQ FROM STANFORD ACHIEVEMENT TEST

TABLE 2
OTIS TEST SCORES
(Chronological age 12 years 5 months)

	Roberta	Mona	Mary	Leota
Total score	61	62	45	59
MA	15–11	16–1	12–11	15–5
IQ	128	129	104	124

tion, Form A; The National Intelligence Tests, Scale A, Form 3, and the Stanford Revision of the Binet-Simon Intelligence Tests.

Tables 2 and 3 and Figure 1 give the detailed results of the intelligence tests Table 4 and Figure 2 give the scores on the Stanford Achievement Tests

TABLE 3
NATIONAL INTELLIGENCE TEST SCORES
(Chronological age 12 years 9 months)

Test	Roberta Score	Mona Score	Mary Score	Leota Score
1	20	18	16	18
2	34	34	26	34
3	42	35	29	42
4	30	31	22	26
5	30	26	16	28
Total	156	144	109	148
MA	15–8	14–11	12-7	15–2
IQ	123	117	99	119

TABLE 4
STANFORD ACHIEVEMENT TEST SCORES (FORM A)
(Age 12 years 5 months Beginning seventh grade)

Test	Roberta	Mona	Mary	Leota
1 Reading Paragraph Meaning	84	76	64	86
2 Reading, Sentence Meaning	58	57	52	62
3 Reading Word Meaning	68	53	50	62
Total Reading Score	210	186	166	210
4 Arithmetic Computation	160	152	128	128
5. Arithmetic, Reasoning	92	104	96	108
Total Arithmetic Score	254	256	224	236
6 Nature Study and Science	57.5	60.5	49	66.5
7. History and Literature	53	52	42.5	60.5
8 Language Usage	32	42	47	48
9 Dictation Exercise	170	164	150	152
Total Score	77.5	76	67	77
Educational Age	15–3	15–1	13–8	15–2

The results of the intelligence and achievement tests show very clearly that the quadruplets developed normally in both the mental and educational traits The scores of Roberta, Mona, and Leota were considerably above the norm for average children of their age Also, their scores are strikingly similar Mary's scores fall almost exactly upon the norms and there is a decided and consistent difference between her scores and the scores of the other three. *Unquestionably*, this difference is significant.

TABLE 5

COMPLETE RECORD OF SCHOOL MARKS

Third Grade

	Read	Spell	Writing	Arith	Gram.	Mu	Draw
Roberta	90	90	85	90	90	80	80
Mona	90	90	85	90	90	80	80
Mary	90	90	95	85	90	80	80
Leota	95	90	90	90	85	80	80

	Gen Aver	Days Pres	Deport.	Promoted to
Roberta	86	171½	90	4th Grade
Mona	86	171½	90	4th Grade
Mary	87	173	90	4th Grade
Leota	87	169	90	4th Grade

Fourth Grade

	Read	Spell	Writ	Arith	Gram	Geo	Draw	Phys
Roberta	95	97	86	96	94	95	85	95
Mona	95	97	87	92	93	95	85	95
Mary	94	97	89	84	91	91	85	92
Leota	95	90	90	90	85	93	85	94

	Days Pres	Days Abs	Deport	Promoted to
Roberta	168	12	95	5th Grade
Mona	168	12	95	5th Grade
Mary	167½	12½	95	5th Grade
Leota	168	12	95	5th Grade

Fifth Grade

	Read	Spell	Writ	Gram	Geo	S Hist	Phys	Arith
Roberta	99	99	89	92	96	97	93	97
Mona	98	99	92	92	94	94	93	97
Mary	83	98	95	91	93	91	90	92
Leota	94	98	88	96	94	92	92	92

	Gen Aver	Days Pres	Days Abs	Deport	Promoted to
Roberta	95	162	18	98	6th Grade
Mona	95	162	18	98	6th Grade
Mary	89	162	18	95	6th Grade
Leota	94	150½	20½	98	6th Grade

Sixth Grade

	Read	Spell	Writ	Arith	Gram	Geo	S Hist	Phys
Roberta	99	99	81	97	98	98	96	97
Mona	97	99	85	95	98	94	94	89
Mary	84	98	88	88	89	88	88	68
Leota	95	99	82	89	93	83	92	77

	Gen Aver	Days Pres	Days Abs	Deport	Promoted to
Roberta	96	170	10	97	7th Grade
Mona	93	173	7	98	7th Grade
Mary	85	171	9	98	7th Grade
Leota	90	171½	8½	98	7th Grade

Table 5 gives a complete record of the school marks given to the four subjects in Grades 3 to 6, inclusive Marks are lacking below the third grade, as the Hollis schools did not keep permanent record of marks prior to the school year 1923-24.

Since it is of general opinion that teachers' marks are somewhat subjective, it is highly possible that there was a decided tendency among the teachers to give the quadruplets the same or nearly the same school marks. In spite of any such tendency, however, there is a closer resemblance between the scores of Roberta and Mona than between the scores of any other pair The reader will notice that the scores of each for drawing and writing are lower than the scores for other school subjects This may be due to the variation in the standard of grading The writer can give no explanation for the comparatively low marks which were given in music in the fourth grade The quadruplets were considered accomplished to a fair degree in both instrumental and vocal music, and at the time of this writing were appearing in a musical program for a theatrical company in the East

The trait ratings for the quadruplet study on the physical, mental, social, and moral traits were made by four women who were neighbors and intimate friends with the Keys family since before the birth of the quadruplets. Also, they were prominent women in the social and political affairs of the town Two of them were the wives of successful business men. The other two were former school teachers and at the time of this writing, one was the County Superintendent of Schools and the other the wife of a prominent physician Our subjects have frequented the homes of these women, who have thus had excellent opportunity to compare them with each other, with their own children, and with other children of the neighborhood.

The trait rating blank used was the one prepared by Terman and Goodenough and used in the study of the one thousand gifted children as reported in *Genetic Studies of Genius* by Terman et al (2). The ratings were made on ten traits or characteristics. The profile chart (Figure 3) gives a graphic representation of the mean rating for each of the subjects.

Masculinity-Femininity Test

The Terman-Miles Masculinity-Femininity Test was the only personality test given Six exercises of an experimental form of this test were given. The scores of each of the six exercises and the per-

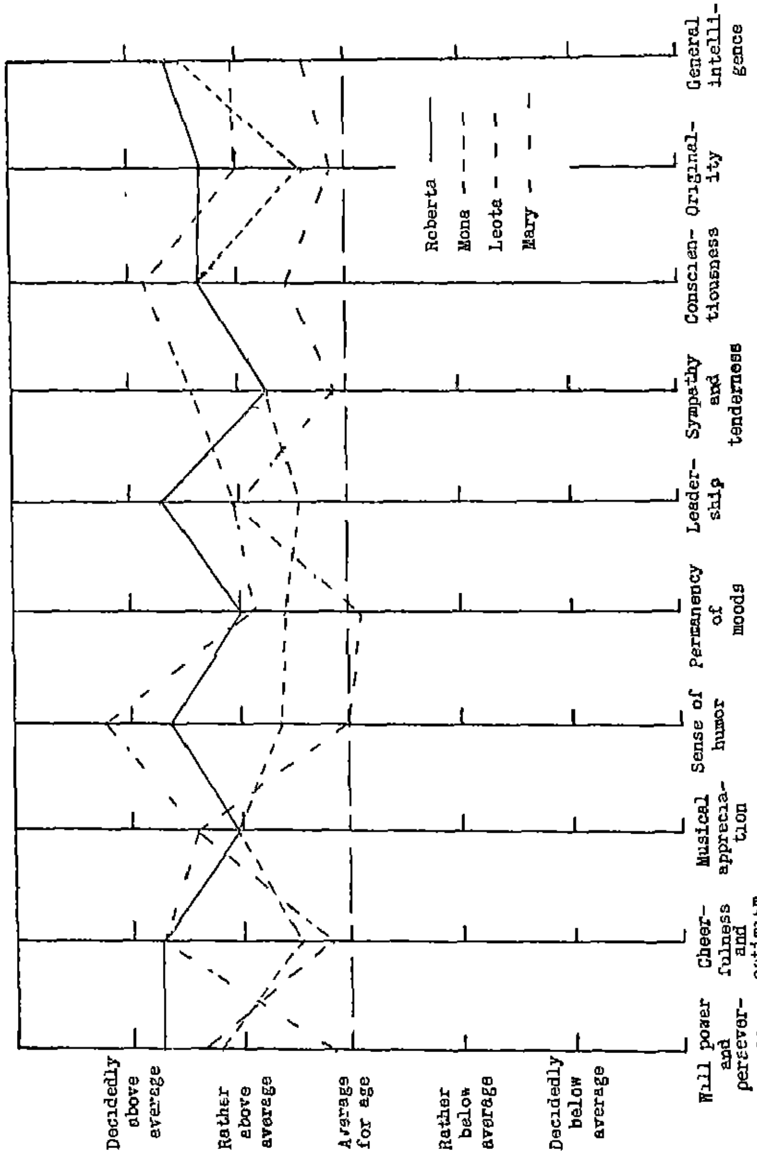

FIGURE 3
Mean Trait Ratings by Four People

centiles reached, in both masculine and feminine traits, are shown in Table 6

TABLE 6
MASCULINITY-FEMININITY TEST SCORES

	Emotions	Roberta	M*	F†	Mona	M	F
1	Anger	164	59 0	14 2	146	30 5	32 0
2	Fear	241	25 0	42 7	216	15 0	59 8
3.	Disgust	300	39 2	20 0	276	21.3	38 1
4	Pity	157	76 3	7 8	151	72 5	8 5
5	Wickedness	205	55.6	19 1	171	12 1	65 9
6	Interest in famous people	393	4 95	73 11	368	1 98	84 83
	Emotions	**Mary**	**M**	**F**	**Leota**	**M**	**F**
1	Anger	160	59 0	14 2	159	59.0	14 2
2.	Fear	177	25.0	88 5	215	15 0	59 8
3	Disgust	264	16 7	23 8	302	39 2	20 0
4.	Pity	128	46 7	26 0	118	35.0	39.1
5.	Wickedness	189	32 2	39 0	201	52.2	24.0
6	Interest in famous people	429	19 8	41 18	371	1 98	84 83

*M. Percentile of masculinity as shown by test
Example. Roberta is as masculine on Ex 1 as 59% of the boys and as feminine on Ex. 1 as 14 2% of the girls
†F Percentile of femininity as shown by test

TABLE 7
SHOWING FREQUENCY OF AGREEMENT ON M-F TEST

Exercise	1	2	3	4	5	6	Total
Roberta and Mona	21	25	16	17	31	19	129
Roberta and Mary	19	16	18	11	29	21	114
Roberta and Leota	17	18	25	12	31	18	121
Mona and Mary	13	18	22	13	34	17	116
Mona and Leota	16	18	14	14	39	14	115
Mary and Leota	18	18	16	20	37	15	124

Table 7 shows the number of times each pair of girls agreed on the six exercises of the Masculinity-Femininity test. The possible score is 278.

As an experimental form of the M-F test was used, the data are probably not very significant. The score earned on a single exercise is known to be very unreliable. It will be noted, however, that Roberta's and Mona's scores are more often in agreement than those of any other pair.

Scholastic, Occupational, and Other Interests

A four-page Interest Blank[3] was filled out by each of the quadruplets. The first page called for ratings on the different school subjects according to preference and ease, the second page contained a list of 125 occupations to be checked so as to indicate vocational preference, the third and fourth pages were devoted to data on reading interests, collections, interest in various kinds of activities, and records of accomplishments and of offices and honors held. A complete report of the responses in the Interest Blank is as follows:

1. *Subjects I like very much*

Roberta	Mona	Mary	Leota
Music (instrumental) Reading U. S. History Arithmetic	Music (instrumental) Music (vocal) Spelling	Reading	Spelling

2. *Subjects that I like fairly well*

Roberta	Mona	Mary	Leota
Music (singing) Penmanship	Reading U. S. History	Penmanship	Music (instr.) U. S. History

3. *Subjects that I neither like nor dislike*

Roberta	Mona	Mary	Leota
Grammar Spelling	Grammar Arithmetic	Drawing (free-hand)	Music (singing) Penmanship

4. *Subjects that I rather dislike*

Roberta	Mona	Mary	Leota
Physiology or Hygiene	Drawing (free-hand) Penmanship	Geography	Geography

5. *Subjects that I dislike very much*

Roberta	Mona	Mary	Leota
No response	No response	U. S. History	Arithmetic

6. *Subjects I like best of all*

Roberta	Mona	Mary	Leota
Games & Sports	Games & Sports	Games & Sports	Reading

[3]The blank was that used by Dr. Terman in his study of gifted children.

INTEREST BLANK (*continued*)

7. *Subject that is very easy for me*

Roberta	Mona	Mary	Leota
U. S. History	U. S. History	Music (instr.)	Reading U. S. History

8. *Subject that is easiest of all:*

Roberta	Mona	Mary	Leota
Spelling	Spelling	Spelling	Spelling

9. *Occupations I may possibly decide to follow*

Roberta	Mona	Mary	Leota
Housewife Clerk Nurse Teacher	Dressmaker Florist Stenographer or Typist Nurse Teacher	Dressmaker Milliner Music teacher	Bookkeeper Accountant Nurse

10. *Occupation I am most likely to choose.*

Roberta	Mona	Mary	Leota
Musician (player)	Housewife	Housewife	Housewife

11. *Occupation I would like best to follow if I could:*

Roberta	Mona	Mary	Leota
Musician (player)	Housewife	Nurse	Expression teacher

12. *Do I prefer the duties of housewife to any other occupation?*

Roberta	Mona	Mary	Leota
No	Yes	No	No

13. *Kind of reading I like*

Roberta	Mona	Mary	Leota
Travel stories Detective stories Bible stories	Fairy stories Travel stories Book of knowledge Current Events History	Nature study	Fairy stories Love stories Stories of home life Bible Current Events

14. *Kind of reading I like very much*

Roberta	Mona	Mary	Leota
Stories of home life Adventure stories Inventions	Adventure stories Bible Inventions	Adventure stories	Adventure stories Plays

15. *Books I have most enjoyed reading the last year*

Roberta	Mona
Tom Slade and *On the River* *Rebecca of Sunnybrook Farm* *Marjorie's New Friend* *When Patty Goes to College*	*Marjorie's New Friend* *When Patty Goes to College* *Rebecca of Sunnybrook Farm*

INTEREST BLANK (*continued*)

Mary	Leota
No response	*Old Fashioned Girl* *Penrod and Sam* *Ruth Fielding of the Red Cross* *When Patty Goes to College*

16 *Magazines I read*

Roberta	Mona	Mary	Leota
American *Woman's Home Companion* *Holland's* *Cosmopolitan*	*Cosmopolitan* *Ladies' Home Journal* *Junior Home*	No response	*American* *Holland's* *Pictorial Review* *Ladies' Home Journal*

17 *What I like to hear people discuss*

Roberta Politics, old times, family history, trips, adventures
Mona Family history, movies, wars
Mary: Fishing trips, and all such sports
Leota What the old people talk about when they were young and what they did

18 *I like to do this thing very much.*

Roberta General reading, (books, magazines, newspapers)
Play games that require lots of exercise
Play with several other persons.
Going to parties, picnics, dances, club meetings
Using tools or working with apparatus and machinery.
Mona Playing games that require lots of exercise
Playing with several other persons
Sewing, cooking, knitting, housework, etc
Mary Playing games that require lots of exercise
Leota General reading (books, magazines, newspapers)
Practicing music, drawing, dancing, etc
Going to parties, picnics, dances, club meetings.

19 *I like this fairly well*

Roberta: Being leader in a team or club and managing other persons.
Mona. General reading (books, magazines, newspapers)
Playing games that require little exercise
Going to parties, picnics, dances, club meetings
Being leader in a team or club and managing other persons
Mary Sewing, cooking, knitting, housework, etc
Leota Playing games that require lots of exercise
Sewing, cooking, knitting, housework, etc

20 *I neither like nor dislike these*

Roberta No response
Mona Practicing music, drawing, dancing, etc
Using tools or working with apparatus and machinery
Mary Playing games that require little physical exercise
Leota Studying lessons, playing games that require little physical exercise, playing with several other persons, playing with one other person, playing alone.

INTEREST BLANK (*continued*)

21 *I rather dislike these*

Roberta Playing games that require little physical exercise, playing with one other person.
Mona: Studying lessons, playing with one other person.
Mary Playing alone
Leota: Using tools or working with apparatus and machinery.
Being a leader in a team or club and managing other persons.

22. *I dislike this very much*

Roberta: Studying lessons, practicing music, drawing, dancing, etc. Playing alone, sewing, cooking, knitting, housework, etc
Mona: Playing alone
Mary. General reading (books, magazines, newspapers)
Leota: No response

23 *The collections I have made.*

	Things collected	Age at time	How many
Roberta	pennies	10 yrs.	150
	pens	9	575
	lead	12	some
	tinfoil	10	1 lb
	dolls	8	4
	recipes	12	25
Mona	Materials for dolls	12	a medium box full
	collecting pennies	10	150
	straight pins	10	500
	small boxes	9	15
	materials of lead	12	not very much
	tinfoil	9	½ lb
	recipes	12	15
Mary	doll dresses		100
	material for such		
	pins		100
	pennies		
Leota	recipes	12	
	shells	12	20

24. *What I have made, invented, or constructed:*

	Things done	Age	Was it very good, fairly good, or poor?
Roberta	made a sled	11	fairly good
	made a guinea pig pen	12	very good
	kite	12	fairly good
	dog house	11	fairly good
	play apparatus	10	very good
	doll furniture	12	fairly good
	work shop	12	fairly good
Mona	Sled	11	fairly good
	dog house	10	fairly good
	sail wagon	10	very good
	work shop	11	poor
	play apparatus	11	fairly good
	made kites	10	very good
	doll furniture	10	fairly good

INTEREST BLANK (*continued*)

Mary	Stilts	10	no response
	playhouse	11	
Leota	made a cake	12	
	made candy	12	

25 *Do I have a workshop?*

Roberta	Mona	Mary	Leota
yes	yes	yes	no

26 *What do I do in it?*

Mona	Melt and mould lead
Roberta	Melt and mould lead
Mary	Melt sheet iron and lead
Leota	

27 *Offices, positions, and honors I have ever held*

	Position or honor	Age at time
Roberta	Scholarship prize	11 yrs.
	Actor in play	8
	Actor in operetta	11
	Sunday School officer	10, 11, 12
	Officer in other church work	10, 11, 12
	Officer young peoples' organization	11, 12
Mona	Sunday School officer	9, 10, 11, 12
	Actor in plays	7, 10, 11
	Actor in operetta	11
	Officer young peoples' organization	9, 10, 11, 12
	Scholarship prize	12
Mary	Chorister	11, 12
	Group Captain	12
	Social	12
Leota	Sunday School officer	11
	Actor in plays	10, 11, 12
	Scholarship prize	9
	Chorister	12

28 *Do I prefer to be with people who are older, younger, or the same age as myself?*

Roberta	the same age as myself
Mona	the same age as myself
Mary	the same age
Leota.	the same age as myself

29. *How old is your best chum?*

Roberta	12 years old.
Mona	12 years old
Mary	9 years old
Leota	12 years old

Frequency of the same response (by same response is meant that a given pair agree in one or more of the items mentioned under a given question) as given by the two members of each pair was as follows:

Possible number	29
Roberta and Mona	21
Roberta and Leota	14
Roberta and Mary	11
Mona and Mary	9
Mona and Leota	16
Mary and Leota	8

The mean number of collections made by the control group of twelve-year-old girls reported by Terman (2) is 1.54 collections. The numbers of collections made by the quadruplets were as follows: Roberta 6, Mona 7, Mary 4, Leota 2.

We see, therefore, that Roberta's and Mona's responses are more in agreement than those of any other pair of the quadruplets.

Summary and Conclusions

1. *Probable Origin.* Apart from the examination of the placenta and foetal membranes at birth it is generally believed that there is no absolutely safe criterion for distinguishing identical twins from fraternal twins. Doctor Siemens, however, states that, "the majority of twins are so completely alike or so markedly different that we can scarcely entertain a doubt as to their identity or non-identity as the case may be."

Roberta and Mona are strikingly alike in form of face, color of hair and eyes, and in body build. Mary and Leota are distinctly different from each other in these respects. Mary resembles Roberta and Mona but has decidedly different form of face and body build. Leota, with her blond hair and blue eyes and distinctly different form of face and body build, is no more like her three sisters than if she were an ordinary sibling. It seems probable, therefore, that Roberta and Mona are identical twins and that the four individuals developed from three eggs.

2. *Traits upon Which Random Environmental Influences Have Had the Most Effect.* Assuming Roberta and Mona to be identical twins, a comparison may be made of the results on their traits that were measured. Although there were slight differences in the physical measurements, the two are as nearly alike as identical twins ordinarily are. From the results of the series of measurements reported herein, we do not find any striking differences between Roberta and Mona. On the other hand, the results of both the physical and psychological measurements show a marked degree of similarity. It

seems, therefore, that with this particular set of twins random environmental influences have had no marked effects on the traits measured

3. *Application of Nature and Nurture Hypotheses.* In studies of identical twins their striking similarity is sometimes attributed to the identical environment Therefore, from a study of a set of quadruplets in which we have both a set of identical twins and a set of fraternal twins who were reared under the same environmental conditions, it appears that random environmental influences have had very little or no effect in causing the identical twins to grow more unlike. Furthermore, it does not seem that the fraternals have become more like the identicals, but rather that factors of heredity have been most influential

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QUELQUES MESURES MENTALES ET PHYSIQUES D'UN GROUPE DE QUATRE ENFANTS AGÉES DE DOUZE ANS, NÉES D'UN MÊME ACCOUCHEMENT

(Résumé)

On a fait cette étude dans le but d'inscrire grand nombre de mesures physiques, psychologiques, et relatives à l'éducation, d'un groupe de quatre filles, âgées de douze ans, nees d'un même accouchement

Au moins trois problèmes importants psychologiques et biologiques se rattachent à cette étude

(1) Celui de déterminer, si possible, si deux ou plus des membres de ce groupe d'enfants nees d'un même accouchement sont du type "identiques" Il semble probable que deux de ces enfants sont des jumelles Identiques et les deux autres des jumelles Fraternelles C'est-à-dire, les quatre enfants se seraient développées de trois oeufs

(2) Celui de trouver les traits sur lesquels les influences au hasard du milieu ont le plus influé

Considérant deux des filles comme jumelles Identiques, on a fait une comparaison des traits mesurés et on n'a trouvé nulles différences frappantes

(3) Celui de tracer le développement des sujets à la lumière des hypothèses de nature et d'éducation

Dans les études de jumeaux identiques on attribue quelquefois leur similarité frappante au milieu identique Aussi, selon une étude d'un groupe de quatre enfants nées d'un même accouchement où il paraît que nous ayons un groupe de jumelles identiques et un groupe de jumelles fraternelles élevées dans les mêmes conditions du milieu, semble-t-il que les influences au hasard du milieu n'aient eu que très peu d'effet ou nul effet à faire que les jumelles identiques deviennent moins semblables. D'ailleurs, il ne semble pas que les jumelles fraternelles soient devenues plus semblables aux jumelles identiques, mais plutôt que les facteurs de l'hérédité aient le plus influé

BRINTLE

INTELLIGENZ- UND KÖRPERMESSUNGEN AN EINER SIPPSCHAFT ZWÖLF-JAHR-ALTER VIERLINGSKINDER

(Referat)

Ziel dieser Untersuchung war es, eine grosse Anzahl physiologischer, psychologischer, und padagogischer Messungen an einer Vierlingskindersippschaft bestehend au vier zwolfjahrigen Madchen aufzuzeichnen Es sind wenigsten drei wichtige psychologische und biologische Aufgaben mit dieser Untersuchung verbunden

1) Wenn moglich, festzustellen, ob zwei oder mehr von den Mitgliedern dieser Vierlingssippschaft dem "identischen" Typus angehoren Es ist wahrscheinlich, dass zwei der Vierlingskinder identische Zwillinge und die anderen zwei geschwisterliche Zwillinge sind, d h, die vier Individuen haben sich wahrscheinlich aus drei Eiern entwickelt

2) Die Eigenschaften herauszufinden, worauf die Umgebung den grossten Einfluss ausgeubt hat Es wurde angenommen, dass zwei der Madchen identische Zwillinge Waren, die gemessenen Eigenschaften wurden unter sich verglichen und es zeigten sich keine ausgepragten Unterschiede

3) Die Entwicklung der Versuchspersonen im Lichte der Hypothesen der Vererbung einerseits und der Umgebung anderseits zu verfolgen

In Untersuchungen an identischen Zwillingen wird ihre auffallende Ahnlichkeit manchmal der identischen Umgebung zugeschrieben Jedoch scheint diese Untersuchung an einer Vierlingssippschaft welche sowohl ein Paar identische wie ein Paar Geschwisterzwillinge enthalt anzudeuten, dass zufallige Einflusse aus der Umgebung Nichts oder nur wenig dazu beitragen, Entwicklung von Ungleichheit zwischen den identischen Zwillingen zu fordern Überdies scheint es nicht, das die Geschwisterzwillinge mehr den identischen ahnlich geworden sein Vielmehr sind die Vererbungseinflusse die wirkungsvollsten gewesen

BRINTLE

SHORT ARTICLES AND NOTES

NOTICE OF SPECIAL VOLUME

CARL MURCHISON

Along with most of the other psychological journals, we have been facing for some time the problem of diminishing the large number of manuscripts which have been accumulating steadily in our files and which have resulted in lengthening unduly the amount of time necessary to get a manuscript published after it has been received from its author This problem has been met in various ways by some of the other psychological journals, and we have finally decided on a method which to us seems wisest under the circumstances

We have decided to publish an entire volume in one issue, this issue to appear between two current volumes This method will result in the saving of an entire year and will clear our files to within approximately six months of publication We have decided on this method chiefly because it adds no additional financial burdens to the author and extends to all authors alike equal benefits in the reduction of the length of publication time

This volume, Volume 38, will not be sent out on subscription, nor will it be involved in the Club Rate plan It must be ordered directly by each subscriber at the regular subscription price of $7 Volume 39 will be issued as the current volume during the year 1931

DIFFICULTY IN THE LEARNING OF SHORTHAND CHARACTERS BY BRIGHT AND DULL CHILDREN

F T WILSON

In a previously published study (1), the learning of bright and dull children was compared in the task of learning to recognize 26 shorthand characters It appeared from that study, that, for four groups of children,

an average difference of 30 IQ points more than compensated for a difference of three chronological years.

This report gives the result of further study of the groups in this task in regard to the difficulty of learning to recognize the various characters Data for the groups are given in Table 1, five additional cases having been included in the later study.

TABLE 1
DESCRIPTION OF SUBJECTS

	Dull 9		Bright 9	Dull 12		Bright 12
Number of cases	15		18	17		15
Average CA	9– 1		9– 2	12– 2		12– 2
CA range	8–11	to	9– 4	12– 0	to	12– 5
Average MA	7– 9		10– 5	10– 4		13– 11
Average IQ	85		114	85		115
IQ range	80–90		110–120	80–90		110–120

Detailed explanation of the experimental procedure may be found in the earlier publication cited above. Briefly, the task was to memorize the appearance of the characters and to give the words for which each stood when the characters were presented without the words Practice consisted in reading from a card on which the words were typed Over each word was written the shorthand character standing for the word. The material was an explanation of the game "Duck on the Rock" Reading was guided by the pencil of the experimenter and the subject was repeatedly reminded to look at the shorthand characters as he read the words The subjects' eyes were carefully observed to make sure that the characters were fixated There was presented to the subjects after each practice a card upon which all the characters appeared. No words were on this card and the order in which the characters were placed was different from that on the practice card The subjects indicated the characters they thought they knew and gave words for them. Record was made of all responses, both correct and incorrect answers being set down Facsimiles of the practice and test cards and detailed explanation of the procedure of the task are given on pages 14 and 15 of the study referred to above.

DIFFICULTY AS INDICATED BY SCORES

The scores used in this study are in terms of the percentage of subjects in each group giving correct answers Table 2 shows these scores and gives the rank order of the characters by the four subject groups and for the total number of subjects as one group.

From this table it appears that all subject groups placed the same six characters at the top of the list and pretty much in the same order Four of these characters are relatively large, both in total size and in the loops which are used in their construction. The other two are the dot and small

TABLE 2
RANK POSITIONS OF CHARACTERS AND SCORES FOR EACH GROUP AND TOTALS

Total		Dull 9		Bright 9		Dull 12		Bright 12	
Ch	Sc	Ch	Sc	Ch	Sc	Ch	Sc	Ch	Sc
	240		62		40		72		83
	236		45	.	39	.	72		82
.	207	.	29		34		58	×	69
×	136		13		23		38	.	67
	109		11	×	21	×	35		47
	108	×	11		17		25		43
	59		11		12		14		33
	55		9		11		13		33
	38		7		10		11		25
	37		7		10		8		25
	37		5		9		6		21
	37		5		9		6		20
	37		4		8		6		19
	36		4		8		6		15
	34		2		7		6		15
	31		1		7		5		15
	30		1		5		5		13
	26		1		4		4		11
	23		1		4		4		11
	19		1		4		4		8
	18		1		3		2		7
	17		0		1		1		7
	17		0		1		1		7
	8		0		1		1		6
	7		0		0		0		1
	1		0		0		0		1

cross mark Furthermore, in the case of each group, except the dull-nine, these six characters have scores which set them off very markedly from *the next character just below In the case of the dull-nine, the fifth, sixth,* and seventh characters have the same score and the next one is only two *score points lower It is interesting to find that dull-nine places* "did" second, although all other groups placed it first. "Large" is at the top of the list for dull-nine, outscoring "did" 62 to 45

Noting next the characters at the bottom of the lists it appears that, with a few exceptions, the lowest eight characters are the same for all groups All of these characters are relatively small Furthermore, they are made either with curved lines, with hooks added to short lines, or with joined lines, hooks, or loops. Apparently the kind of strokes and the complexity of the figuration account in part for the low scores of these characters.

Two characters, those for "duck" and "every," belong to the group of large characters, but are found among those in the middle of the rank order lists for all groups The symbol for "every" is complicated by the inclusion of a small circle at the upper end of the stroke The symbol for "duck" is complicated by a hook and the addition of a small curve at the end of a long straight line Apparently the factors of complexity of the character and the use of small hooks and lines make a difference in the difficulty of recognizing characters once studied Those characters which are large in size and simple in structure seem to be more easily recognized These differences in difficulty, however, seem to be very much the same for dull and bright and for younger and older children

Two small characters, the dot for "a" and the cross for the "question mark," ranked among the first six highest characters Perhaps the simplicity of these symbols and also their probable familiarity account in part for their high scores The dot has been encountered by all school children as the period, as part of the letter "i," as a counting symbol in commonly found bad habits of addition, and in many other connections Small crossed lines have been met with, as the printed letter x, as the sign of addition, and as a symbol in many other uses in art, games, and the like None of the other 24 characters has such common symbolic uses

The relation of first scores to last and to total scores may show differences of interest in regard to the learning progress of the bright and the dull groups For the purpose of discovering such relationships correlations between first, last, and total scores were secured They are given in Table 3 Correlations were computed by the rank order method.

Last score and total scores correlate most closely This would be expected, since the last scores contributed more to the total scores than did any others First and last scores correlated the lowest except in the case of dull-nine, where the figure is higher than that for first and total. Of the four groups bright twelve has the highest average of the three correlations, but has the same score as that of the dull-nine for the correlation of the first and

TABLE 3

Correlations of First, Last, and Total Scores

	Dull 9	Bright 9	Dull 12	Bright 12	Total
First and total	791	732	753	860	.915
First and last	801	700	654	801	.867
Last and total	908	882	921	915	952
Average	833	771	.776	859	911

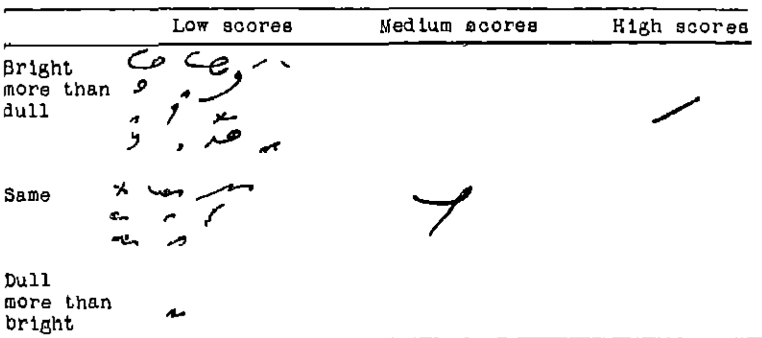
last scores Dull-nine comes next to bright-twelve in the average of its correlations. Bright-nine and dull-twelve average about the same, but the figures vary from 654 to 921 About all that can be said in regard to these correlations is that they are high and positive with an indication that bright-twelve have higher correlations than the other groups Apparently first learning as measurable by a score may not be very highly indicative of final achievement It may be higher for older and brighter children than for younger and duller

Difficulty as Indicated by Gains

Gains were measured by finding the arithmetical differences between first scores, derived from the first two trials and final scores, derived from the last two trials of the learning series The two dull groups were combined for this part of the study, and the two bright groups likewise were combined. The resulting totals were compared The data do not warrant fine discriminations, and, therefore, the comparisons are only roughly drawn From tables giving these data Diagrams 1 and 2 have been used In Diagram 1 are shown all the characters of the selection arranged according to gains.

DIAGRAM 1

Comparative Gains of Bright and Dull by Characters



In Diagram 2 are shown the rank order positions of the characters according to the total scores given in Table 2 Along the first rows of each diagram are those characters which showed greater amount of gain by the bright than by the dull groups. Along the second row are the characters which showed about the same gains In the third row is shown the one character for which the dull made more gain than the bright groups The columns indicate the relative size of scores—low, medium, and high

DIAGRAM 2
COMPARATIVE GAINS OF BRIGHT AND DULL BY RANK POSITION OF CHARACTERS

	Low scores	Medium scores	High scores
Bright more than dull	5, 6, 7, 8 9, 10, 11 13, 14, 15 17, 18, 21, 22	3	1
Same	4, 12, 19 20, 23, 24 25, 26	2	
Dull more than bright	16		

Studying the facts shown in these diagrams, it seems that, for all the characters for which the scores were high, the gross gains were greater for the bright than for the dull, except for "large," in which case the gains seem to have been about the same. There are in this group, however, a few of the characters for which total scores were low From the second row it appears that, with the exception of "large" and "question mark," those characters for which gains for bright and dull were about the same were the more difficult characters The explanation of the apparent same gains for "large" and "question mark" is, in part at least, that bright-twelve scored so high at first on each of these characters that comparatively little arithmetical gain was possible Both dull groups, on the other hand, made low first scores and relatively high last scores, so the difference was quite large

The case showing greater gain by dull than by bright, made on the character "one," seems to be a chance result due to an apparently exceptional gain in score from 0 to 26 by dull-twelve, as compared with 0 to 3 by dull-nine, 3 to 8 by bright-nine and 0 to 13 by bright-twelve The difference probably does not represent the true relationship between bright and dull groups in this particular, and occurs largely because of the limited number of cases.

DIFFICULTY AS INDICATED BY ERRORS

Errors in this task had two aspects. One was mistaking the identity of a character The other aspect was giving a wrong word. The first indi-

TABLE 4
NUMBER OF ERRORS IN IDENTIFYING EACH CHARACTER

Total		Dull 9		Bright 9		Dull 12		Bright 12	
Ch	Sc	Ch	Sc	Ch	Sc	Ch	Sc	Ch	Sc
	147		67		33		45		34
	146		50		28		39		32
	130		43		23		37		29
	122		41		26		34		26
	116		39		26		33		24
	111		36		25		32		23
	106		33		25		29		22
	97		33		23		27		22
	92		33		21		26		21
	86		31		20		24		21
	85		30		17		22		17
	76		30		17		22		16
	75		26		15		21		14
	75		23		14		19		14
	74		23		13		19		13
	72		23		12		18		13
	69		22		12		18		13
	68		20		12		18		12
	63		20		11		17		12
	63		18		9		16		11
	57		18		8	.	16		10
	57		17		8		15		9
	56		13		8		15		5
	52		12		6		13		5
	42		12		5		11		4
.	33	.	10	.	4		10	.	3
Total	2170		723		426		596		425

cated a partial recognition of a character The other indicated the recollection of a word, but an error in associating it with a character. The rank order of these errors and the scores for each by groups are given in Tables 4 and 5 The scores in these tables are the number of errors made

TABLE 5
NUMBER OF ERRORS IN USING WRONG WORD, BY WORDS*

Total W	Sc	Dull 9 W	Sc	Bright 9 W	Sc	Dull 12 W	Sc	Bright 12 W	Sc
rock	218	rock	75	rock	52	every	44	rock	61
the	162	every	61	who	39	play	44	the	47
every	156	the	50	duck	32	duck	42	duck	42
you	155	you	46	it	28	on	40	you	36
duck	151	stone	41	the	25	the	40	it	30
it	131	off	41	every	24	it	40	every	27
play	117	knock	40	his	23	his	35	play	26
his	101	did	37	a	19	you	34	his	25
stone	93	duck	35	play	18	knock	30	knock	17
knock	92	a	34	stone	18	rock	30	on	14
on	90	it	33	on	16	stone	22	stone	12
a	74	player	32	knock	15	off	18	has	11
off	72	play	29	others	13	period	17	each	10
player	57	others	21	who	11	a	14	others	10
others	52	on	20	period	10	player	13	period	8
did	49	his	18	off	10	large	12	a	7
each	45	each	16	has	10	each	11	one	7
period	41	has	13	player	9	has	8	to	6
has	32	one	13	each	8	one	8	try	5
one	31	large	11	to	8	others	8	who	4
large	30	try	11	try	7	puts	7	did	3
try	28	period	6	large	6	try	5	player	3
to	25	to	6	did	5	to	5	off	3
who	22	q. mark	4	q. mark	5	did	4	q. mark	1
q. mark	11	who	4	one	3	who	3	puts	1
puts	11	puts	2	puts	1	q. mark	1	large	1
Total	*2046*		*699*		*415*		*535*		*417*

*Words not found in the selection but named by the subjects for characters are not included in this table

In the case of nearly every character the dull made more errors than the bright. The totals also show the dull to have made more errors than the bright For the aspect of mistaken identity of character the ratio was about 13 to 8 For the aspect of using the wrong word the ratio was about 12 to 8 Dull-nine made the greatest number of errors of each kind The two bright groups oddly enough made almost the same total number of errors of each kind, but this similarity is largely coincidence Character for character, the number of errors for the two bright groups varies considerably

The relation of errors and correct responses is shown in Table 6 This table indicates the correlations between these data as computed by the rank order method.

TABLE 6
CORRELATIONS OF CORRECT RESPONSES AND ERRORS

	Dull 9	Bright 9	Dull 12	Bright 12
Correct responses and identity errors	399	242	209	107
Correct responses and word errors	000	—054	176	—176

Apparently, as far as the elements of this task were concerned, the relation between correct and incorrect responses was quite uncertain Two correlations are practically zero One is negative and low The others are positive and low It may be significant that the bright-twelve correlations happen to average practically zero, but, on the other hand, one of the dull-nine figures is also zero If the learning had been carried further, to a point at which the percentages had been considerably higher than they were for most of the characters, there might have been larger correlation figures But to the point to which the learning went there seems to be no evidence of any important relation between scores for the characters and errors

SUMMARY AND CONCLUSIONS

In this task, requiring the recognition of a particular figuration of strokes and the association of certain known words with each character, difficulty was studied in three respects in connection with four groups of bright and dull children

1 Rank order of scores indicated that achievement in the task was quite clearly related to size of characters, complexity of strokes, and familiarity of the symbols There seemed to be little, if any, difference as to this aspect of difficulty between bright and dull, younger and older children.

2 Gains in scores seemed to indicate that the bright made greater arithmetical gains than the dull on those characters having the higher scores; and that on those characters having the lower scores the bright and the dull made about the same arithmetical gains

3 Errors seemed to indicate that both recognition of a character and association of the correct word with it were responses much more often incorrectly made by the dull than by the bright There seemed to be no significant correlation, however, between errors and difficulty as indicated by high and low scores for any of the groups

It would seem, therefore, that for such learning as was represented by the requirements of recognizing these 26 shorthand characters, difficulty is a complex combination of various elements Three aspects of difficulty were examined None of them was clearly discernible. Probably there were many other elements and probably all elements were combined in

varying proportions for each individual In the aspects examined it seems that bright and dull children differ only in degree and not in kind. There seems to be every suggestion in the data that, in guiding the learning experiences of all individuals, whether bright or dull, young or old, this difference in degree is the important consideration Not all bright subjects scored higher on a given character than any dull subject Not all bright subjects gained more than any dull subject. Not all dull subjects made more errors than any bright ones

This investigation emphasizes once more the regularly repeated conclusion of every study of the learning progress of contrasted groups, that the fundamental problem of guidance is that of fitting the learning situation to the needs of the individual learners It also emphasizes a conclusion steadily becoming more and more certain as scientific evidence accumulates, namely, that the individuals of less native endowment or less fortunate circumstances can make progress in the learning of anything to which they apply themselves. This is true in spite of the fact that frequently the technique of the learning procedure is definitely unsuited to their needs and disadvantageous to their abilities

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State Teachers College
Buffalo, New York

A STUDY OF THE ONLY CHILD AT SCHOOL*

HELEN FERRIS HOOKER

Much of the literature dealing with child guidance and parental education in the past has emphasized the dangers of being an only child Most of the statements were subjective in nature, practically no objective evidence being given to prove them. However, objective studies made recently indicate that the only child is not necessarily peculiar, nervous, and hard to get along with, as earlier writers claimed Goodenough and Leahy (4) decided that any position in the family involved "certain problems of adjustment" (p 70). Fenton (3) concluded that only children were probably only slightly if at all likely to "become peculiar and nervous" (p 550) On the other hand, Wexberg (10) and Lee and Kenworthy (5) believe that adjustment to the school situation is unusually difficult for the child without siblings, and A Busemann (2) concluded from a study of German children

*Abstract of a master's thesis (unpublished) to be found in the Library, University of Pittsburgh, written under the supervision of Florence M. Teagarden, Ph D

that only children from the better social classes are retarded in school. Blatz and Bott (1), however, found by studying misdemeanors among school children that only children had the best records.

In the present study the investigator tried to discover whether the only child at school differs in social and emotional adjustment from one with siblings. The school chosen has a population of about eight hundred pupils and is situated in a district partly residential and partly business. The parents of most of the pupils are American-born and represent all social strata. All of the subjects of this study except two, who were natives of English-speaking countries, were born in the United States.

In most studies no attempt has been made to eliminate factors other than "onliness" which might affect the emotional and social adjustment of the children concerned. In the present study every effort was made to select cases which were free from the possible influence of broken homes, presence in the home of relatives other than the immediate family or any other factors which might have a bearing on the child's behavior. The method of selection was as follows: Homeroom teachers of all grades, including the two kindergarten rooms, were asked to list the children in their rooms whom they knew to be without brothers or sisters. From the 117 names thus secured, through personal interviews, children were selected who lived in a home where there were no relatives except mother and father and who to their knowledge had never had siblings. The following criteria for matching an only child with a child having siblings were used: (*a*) school grade (within one-half grade); (*b*) sex; (*c*) chronological age (within six months); (*d*) nationality (wherever this could be fulfilled in addition to other criteria; (*e*) family organization; (*f*) not more than one child from any one family; (*g*) intelligence quotient (within ten IQ points).

From the school files it was determined what child in the same half grade matched a given only child in sex, chronological age, and nationality as indicated on the child's school registration card. Each "match" thus selected was interviewed to determine whether he lived at home with his parents and without relatives other than his siblings. At this time it was learned also whether he was the oldest child, the youngest, or neither. Later, due to a dearth of "matches," it became necessary to extend the matching to a half grade either above or below the one which contained the only child.

To determine the intelligence quotient the Otis Group Intelligence Test (Form A Primary and Advanced) was given to the only children and those so far matched with them. Fourteen possible "matches" were eliminated by this test and it was, moreover, found impossible to match the intelligence quotients of three of the only children. In each case where there was a discrepancy of more than ten IQ points the whole process of matching had to be repeated. Altogether 203 children were interviewed and 77 were given the Otis Intelligence Test. This rigorous matching left but 30 pairs

of only children and their "matches" for further study There were 14 pairs of girls and 16 pairs of boys Ten of the "matches" were oldest children, 11 were middle, and 9 were youngest children According to the method of classification used by Strayer (7), the age-grade distribution showed that two only children are retarded, 21 are making normal school progress, and 7 are accelerated.

Limitations of space prohibit reproduction here of the research techniques used in this study These techniques were a questionnaire and two rating scales The questionnaire contained 17 questions selected from Terman's (8) adaptation of the Woodworth-Mathews Personal Data Sheet and an eighteenth added by the investigator This questionnaire was filled out verbatim in an interview with each child alone

Although rating scales are a subjective method of determining personality traits, according to Murphy (6) they afford the best means available at present Many rating scales are limited in their scope because they have been designed for a more or less narrow age range The rating scales used by Wickman (9) are especially designed for the elementary school child and therefore seemed better suited than any other to the present study. Two rating scales, A and B, were adapted from Wickman (9, pp 217-228) The items for Scale B were selected for their potentiality to reveal the special maladjustments of the only child

Rating Scale A, the purpose of which was to enable the investigator to discover whether the behavior of the only children was conspicuous when compared with the total school population, was applied by each room teacher to all the children in her room Three teachers who had known the children in class for from four months to two years rated each only child and his "match" on Rating Scale B The same three teachers rated each member of a given pair, thus giving 180 ratings in all

The typical and atypical replies to the Woodworth-Mathews Questionnaire were scored in accordance with Terman's (8) procedure Eighty-one per cent of the answers given by the only children and 88% of those given by the "matches" were typical Nine per cent of the only children's responses and 6% of those given by "matches" were atypical Ten per cent of the answers of the only children and 6% of the responses of the "matches" were scored "uncertain" These represented answers which were inconsistent with others or instances where the child refused to reply definitely "yes" or "no"

The results from Rating Scale A are as follows: 244 (42%) of all the children in the grades used in this study and 17 (57%) of the only children were exceptionally well-adjusted; 243 (41%) of all and 12 (40%) of the only children presented minor behavior difficulties, 84 (14%) of all and 1 (3%) of the only children showed difficulties of some importance, while 16 (3%) of all and none of the only children were considered to present extremely serious behavior problems.

The results of Rating Scale B, statistically treated, yielded the following results only children are slightly *less* likely to be "neglectful, forgetful or irresponsible in duties" which they have been "asked to or expected to perform," they are *less* likely to "become sulky or sullen," they are *less* likely to be "rude, impolite" or "impudent to others," *less* likely to be nervous, i e, "unable to control themselves muscularly," and *less* likely "to be dishonest." They are *more* likely to "show signs of being sissies or tomboys" In all other traits rated the differences between the only children and those with siblings are not significant

Insofar as the results of this study can be compared with the results of Fenton's (3) study there are some slight differences, although the general conclusions are in agreement. Fenton found that only children as a group are more likely to be cheerful and happy while the present results indicate no differences in happiness between the only children as a group and those with siblings Fenton found that only children are more likely to be "disobedient," whereas, although the difference is not significant, the present study indicates a tendency in the opposite direction

Conclusions

1 The current belief that only children in general are sure to present serious behavior problems because of their "onliness" is not substantiated by the results of this investigation

2 Only children in general are not necessarily nervous, hysterical, and "spoiled"

3 Considered as a group and on the basis of chronological age, the only children in this study were not retarded at school

4 According to the results obtained in this study, only children at school as a group probably differ little, if at all, from those with siblings

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University of Pittsburgh
Pittsburgh, Pensylvania

FIRST INTERNATIONAL CONGRESS OF RELIGIOUS PSYCHOLOGY

The First International Congress of Religious Psychology will be held at the University of Vienna from May 26th to May 31st (Week of Whitsuntide), 1931, under the auspices of the International Society for Religious Psychology, the President of which is Karl Beth, D.D., Ph D., Professor of Protestant Theology in the University of Vienna, and the Vice Presidents Franz Brandl, LL.D, Director of the Viennese Police, and Otto Nahihaft, LL.D, First Public Prosecutor

The most important problems of recent religious psychology will be discussed from various points of view, educational, experimental, sociological, psychiatric, pathological, theological, occultistic, etc, the main subject being the psychic basis of the religious unbelief of the present day

Many internationally known scientists are scheduled to deliver lectures or read papers at this Congress.

Opportunities to see the city of Vienna and its important institutions will be amply provided for

Inquiries as to program, facilities, schedule of sight-seeing trips, and all other information should be sent to the International Society for Religious Psychology, Vienna, VII Zittelhofergasse 8, Austria, and should be accompanied by fifty cents in stamps

BOOKS

EDITED BY

EDMUND S. CONKLIN
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BROOKS, F D *The Psychology of Adolescence* Boston Houghton Mifflin, 1929. Pp. 652+xxiii

For two decades the subject of adolescence lay dormant, under the weight of Hall's two volumes During the years following 1907, texts for teachers, dealing with this developmental period of human life, appeared now and again, but nearly all were echoes of Hall's poetic theories and questionnaire methods Teachers began to demand a text which would put students in touch with modern procedures and modern data In response, several new books on adolescence have appeared very recently. Notable among these is the text by Brooks

This text conveys to students of development a scientific survey of facts and methods derived critically from all available sources Areas of ignorance are mapped out, so that inquiring minds, if properly trained, can launch upon further investigation The bibliographies are excellent. The purpose, well achieved, has been to gather and organize the best of what scores of workers have contributed by quantitative methods This is what has long been needed

Every book has a fault, and we find here what might be termed a fault of circumscription The author, instead of assuming a knowledge of general educational psychology, undertakes to supply this to his readers The result is that too much material is covered, which is not particularized to the topic of the book "Learning and Forgetting," "Instincts and Impulses," "Disturbances of Personality," "Statistical Methods," exemplify the topics which are treated at length, although they do not especially pertain to adolescence The time has gone by when the author of a text in a special field of educational psychology should attempt also to cover the field in general

Aside from this fault of failure to circumscribe and focus, the book is the most useful and the most thoroughly documented text at present available in the field of adolescence.

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Teachers College
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New York City

ARLITT, A H. *The Child from One to Six* New York McGraw-Hill, 1930 Pp xix+188

CRAWFORD, N. A, & MENNINGER, K A *The Healthy-minded Child* New York Coward McCann, 1930 Pp viii+198

MATEER, F *Just Normal Children* New York Appleton, 1929 Pp x+294

O'SHEA, M V. *Newer Ways with Children* New York Greenberg, 1929. Pp x+419

Although the several books of this group differ in many respects, they are alike in being intended primarily for the parent rather than for the student of child psychology In attempting to evaluate books of this type, the adequacy with which they seem to meet the practical needs of the layman must be given chief consideration One should not expect to find a systematic and rounded-out treatment, it is enough if topics likely to be of interest to the troubled parent are included and discussed in a simple and straightforward manner

The first volume of the group should prove to be of considerable value to parents in dealing with what is usually regarded as the most critical age of the child The problem of securing obedience in the very young without discouraging the normal development of independence is discussed in the light of our newer knowledge of childhood Most helpful advice is offered relative to the establishment of habits of individual and social reactions at this age The author writes in a simple, clear style, and faces the problems squarely and directly

The second volume consists of a series of lectures to parents on the child and the home by a number of writers The lectures are so general in scope and form of treatment, as to be platitudinous, and the average parent will find little here of genuine practical value

The volume by Mateer makes use of the direct question and answer method, and this mode of treatment will doubtless appeal to many parents. The questions are grouped by topics into 23 chapters, with an occasional delineation of illustrative cases As a rule, however, the answers are much too brief, and while seldom dogmatic are sometimes ambiguous The selection of questions is generally good, although in some cases these appear to be too academic to be of much interest to the parent Perhaps a certain justification for such inclusions can be found in the recent exploitation of

psychological terminology among the masses On the whole, this book should be well received by the intelligent parent

The last volume of the group contains 70 lectures on what appear to be as many problems of the child in the modern home In fact, however, many of the situations discussed belong rather to the school, and the preferred advice should be in a book for teachers In general, each topic is disposed of in a scant half-dozen pages or so by statements that are always general and often platitudinous The primary aim of the volume appears to be to bring the modern parent to realize that many of the petty rules of conduct imposed upon the child a generation ago are less important than were then supposed, and that the ignoring of these rules in the modern home need not mean that the child is not being properly brought up. Doubtless the modern parent needs sermons of this sort occasionally

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POPENOE, P *The Child's Heredity.* Baltimore: Williams & Wilkins, 1929. Pp xiii+316

HIRSCH, N D M. *Twins.* Cambridge Harvard Univ Press, 1930. Pp. 159.

PATERSON, D. G *Physique and Intellect* New York. Century, 1930. Pp xvii+304

FRANZEN, R. *Physical Measures of Growth and Nutrition* New York American Child Health Association, 1929. Pp xii+138

ROSE, M. S, & GRAY, C E. *The Relation of Diet to Health and Growth of Children in Institutions* New York Bur. Publs, Teach Coll, Columbia Univ, 1930 Pp vii+128

The first volume of this group is an excellent manual for parents in all things pertaining to the heredity factor in the development of the child. The author approaches the problem from a broad biological standpoint, presenting the known facts concerning the genetic background of the child in simple, non-technical language for the most part The treatment is systematic and covers such varied aspects of development as structure, function, and intelligence. Although the emphasis is upon the normal child, disorders of development are not neglected There is a special chapter on left-handedness and another on the problems of sexuality The book is well illustrated and contains a bibliography of 418 titles This volume deserves to be read by every intelligent parent, although occasional difficulties are likely to be encountered because of the difficulty of explaining certain complex biological processes in simple, non-technical language.

The little volume by Hirsch on twins is a valuable contribution to the experimental literature on this special phase of the heredity-environment problem The first three chapters deal with numerous general aspects of

the phenomenon of twinning, while the fourth chapter constitutes a very inadequate survey of previous tests made upon twins The remainder of the volume is devoted to the experimental work of the author, and this must be considered as the main contribution. The author is convinced that he has been able to isolate the hereditary from the environmental factor in development fairly well at least Moreover, he is convinced that the hereditary contribution is several times as important as the environmental in human development, being more effective in such general traits as intelligence than in bodily weight and other special traits He holds that heredity and environment should not be looked upon as essentially antagonistic since the higher the type, the greater may be the modifying influence of environment The results of the author must be finally evaluated, however, in the light of the cumulative evidence resulting from many and various types of approach to this general problem Definite conclusions of the sort drawn by Hirsch must be considered as entirely premature.

The volume by Paterson fills a real need in the field of individual differences. The problem of individuality is approached from a broad biological standpoint An attempt is made to correlate various morphological and physiological indices with scores of behavior traits and intelligence Comparisons are made between such factors as height, weight, cranial capacity, anatomical age, morphological index, physical condition, and glandular constitution and the commonly accepted norms of behavioral adequacy and intelligence. It is impossible to indicate in this brief review the conclusions reached in the case of the several comparisons made. However, the general negative trend of the evidence, as interpreted in the final chapter, would seem to suggest the need of a re-evaluation of both types of scores involved in the comparisons Either a new anthropometry and physiology must be developed which bears some fairly close relationship to what the psychologists measure, or the notion that physique and intellect are related in any important way must be abandoned The volume is exceedingly stimulating and should be widely read by both psychologist and anthropologist.

The last two books of this group are monographs of somewhat limited scope The first is concerned with the problem of the relation between the nutritional status of the child and such indices of development as weight, size of muscles, symmetry, etc The monograph is replete with tabular material covering measurements of the sort indicated on both sexes at various age levels. The book by Rose and Gray deals with the influence of nutrition on the health and growth of children in institutions The effect of various diets, under such relatively standardized conditions, is determined Practical suggestions are also offered as to the best diet for institutional children.

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$7.00 per volume
Single numbers $2.00

QUARTERLY

June, 1931
Volume XXXIX, No. 2

Founded by G. Stanley Hall in 1891

THE PEDAGOGICAL SEMINARY AND JOURNAL OF GENETIC PSYCHOLOGY

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Entered as second-class matter August 3, 1897, at the post-office at Worcester, Mass., under Act of March 3, 1879

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Chaque article est suivi d'un résumé en français
Jedem Artikel wird ein Referat auf deutsch folgen

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Entered as second-class matter August 3, 1897, at the post-office at Worcester, Mass, under Act of March 3, 1879

STUDIES OF ANIMAL RETENTION: I. NOTES ON THE RELEARNING OF A MULTIPLE-T MAZE BY ALBINO RATS*

From the Psychology Laboratory, Stanford University

QUINN MCNEMAR AND CALVIN P STONE

There is a dire lack of reliable information on the retentiveness of rats as judged from the scarcity of systematic investigations reported in the literature [See the paper by Schneck and Warden (6) for an extensive review.] Of eight studies dealing specifically with the subject, only four present data in sufficient detail or have populations sufficiently large to warrant any suggestive conclusions.

Basset (1), giving his rats five trials per day on a Watson circular maze and requiring them to make five perfect runs on each of three successive days for both learning and relearning, found that with a retention interval of 60 days the saving in days to meet the criterion was 65% and 77% respectively for groups of 12 inbred and 12 control rats Studying the problem of redintegration, Brockbank (2), using four groups of animals, 4 to 10 per group, failed to find consistent results on savings for retention intervals of 30, 45, and 70 days. Because of the great individual differences in his animals on learning, relearning, and savings, however, one should not be surprised at finding inconsistencies with such small groups.

Special points of interest to which Brockbank called attention are the suggestions that: the difficult alleys for the learning trials are likewise points of greatest difficulty on relearning; previous training not only lowers the rate of the original learning, but also increases the amount of savings, relearning a maze is accomplished in fewer trials if practice is distributed rather than concentrated in the original series; and the task of learning another unrelated problem during the retention interval does not result in an increase in relearning trials. Ulrich's chief interest (13) centered in ascertaining what modifications of reflexes were associated with the process of learning and relearning, rather than the measurement of retention as conceived in the present article He did not present tabular data indicat-

*Received in the Editorial Office, August 29, 1930

ing the amount of savings on redintegration, yet in many respects his results for a latch box, inclined plane, and Watson circular maze appear to corroborate the general conclusions of Brockbank Individual differences in the first relearning trials of his rats after intervals of 30 and 75 days appeared to mask group tendencies as measured by the conventional criteria of learning

Stone (8) has shown that various groups of rats which began learning a simple platform box at the ages of 50, 70, and 120 days, 8 months, and 2 years were able to escape as quickly after a few trials of relearning (retention interval, 70 days) as in the final trials of the learning series Some evidence that the former detrimental as well as beneficial habits were recapitulated by all of the age groups in the early phases of relearning was given No consistent relationship between age and proficiency of relearning was demonstrated. More striking illustrations of habit retention for problem box habits were afforded by various age groups retrained on a triple platform box after an interval of approximately 50 days The mean time for escape dropped after one or two trials to the level reached at the close of the learning period and thereafter continued to decline at a slow rate. Although in the early trials of learning the younger groups effected their escape more quickly than the middle-aged or older groups, little difference between the age groups was found at the end of the learning period and throughout relearning. Different age groups retrained on a modified Carr maze after a retention interval of 70 days, within 2 to 6 trials, as a rule, reduced their mean time to the level achieved in from 16 to 20 trials of original learning. Retracings were no more numerous throughout relearning than at the close of the learning trials. As to forward-going errors, however, the case was somewhat different. Most of the groups reached the level at which they closed the 20 trials of learning within 4 to 10 trials, but one old group, over two years of age, did not at any time in the relearning series reach the low level made in the original Inspection of the individual scores of this group shows that the inferior mean relearning record was due, primarily, to the influence of three animals which made extremely poor records. If these records were dropped from the group's data, the curve of the old group would have reached its former level within approximately 14 to 16 trials. We were unable to determine conclusively whether the results of this old group are indicative of an age effect on retentivity, but the results strongly suggest that this may have been the case

The most systematic study reported is that of Tsai (*11*), who ran seven groups of 12 rats each on a Carr-type maze and then gave retention tests after varying intervals of time His criterion was three perfect runs, and the groups were so selected that means on the learning were approximately equal In Table 1 we give his results in terms of percentage saved as based on error scores Tsai plotted these results and obtained a linear curve of forgetting from which he concluded that the forgetting of rats does not follow the Ebbinghaus curve for humans However, to the reviewer, it would seem that with larger numbers and longer intervals between learning and relearning there may not be a linear relationship.

TABLE 1
TSAI'S RESULTS

Retention interval in days	7	14	21	28	42	56	84
Per cent savings	95	94	90	86	80	78	60

SOURCE OF DATA FOR THE PRESENT REPORT

The data herewith presented are a by-product of another study and were collected under working conditions that did not permit of a systematic study of the problem of retention. Nevertheless, the data were collected with all the care that would have been exercised in a more systematic program Therefore, they should be adequate for indicating some of the more important factors one should take into account in a well-planned systematic study of retention The data were obtained from a multiple-T maze of 12 units. Only foreward-going errors (Stone and Nyswander, 10) were considered Some of the animal groups were also trained to discriminate lights and to open the door of a simple and a triple platform box in conjunction with their maze training Thus the experimental background of each group must be taken into account when making comparisons of either their original or their relearning scores This we have done. The aforenamed pieces of apparatus and technique of experimentation appropriate to each have been described elsewhere, hence no further comments seem necessary. The reader may refer to references 8, 9, and 10 of the bibliography for an account of the multiple-T maze, the discrimination apparatus, and the simple and triple platform boxes Each animal was strongly motivated by hunger and received only one trial daily on any of the instruments.

TABLE 2

LABORATORY HISTORY OF THE VARIOUS ANIMAL GROUPS BY AGE INTERVALS

Group	*Ages—beginning and end of learning* Simple platform box	Triple platform box	Discrimination box	Maze	*Ages—beginning and end of relearning* No activity	Triple platform box	Discrimination box	Maze	Intermaze interval (days)
A	21–25	26–65	21–60	61–90	91–110	111–130	111–130	131–145	40
B	21–25	26–65	66–95	66–95	96–115	116–135	136–150	136–150	40
C	76–80	111–135	111–135	81–110	136–155	—	—	156–170	45
D	76–80	81–120	76–115	116–145	146–165	166–185	166–185	186–200	40
E	293–297	328–342	328–342	298–327	343–362	—	—	363–377	45
F	358–363	395–419	395–419	364–393	420–439	—	—	439–453	45
G	86–90	—	—	91–120	121–237	simple 238–240	—	241–255	120
H	146–150	—	—	151–180	181–299	simple 300–302	—	303–317	120
J	211–215	—	—	216–245	246–388	simple 389–391	—	392–416	147
K	268–272	—	—	273–302	303–424	simple 425–427	—	428–442	125
L	370–375	—	—	376–405	406–529	—	—	530–544	124
N	20–25	—	—	26–55	56–145	—	—	146–160	90
M	20–25	—	—	26–55	56–115	—	—	116–130	60
O	20-25	—	—	26-55	56–85	—	—	86–100	30

To provide the reader with an epitome of information concerning ages, course of training, retention intervals, etc., for each group of animals studied or compared, we have brought together such data in Table 2 Considering Group A as an example, Table 2 shows that it began on the simple platform box at the age of 21 days and continued for five days, at the same age training on the discrimination apparatus was begun, and this continued for 40 days After the simple platform box, Group A was transferred to the triple platform box where it received daily trials until the age of 65 days. Maze training followed the trials on the discrimination box during a 30-day period At the age of 90 days the group was given a respite from training which lasted 20 days The retention tests on the triple platform and discrimination apparatus began when the group was 110 days of age This relearning period lasted 20 days and was immediately followed by a 15-day relearning test on the maze. Between the last trial of the original maze series and the first trial of the relearning test 40 days elapsed This interval is called the intermaze or retention interval, and is the time factor with which we are chiefly concerned in this study

Methods for Comparing Groups

In order to make comparisons, it is necessary to adopt methods by which the varying retentivity of certain groups can be characterized with reference to the other groups Since no standard schemes are available for this particular situation, we are using several methods which seem to supplement each other. namely, graphical comparison of 30 trials of learning and 15 trials of relearning; the average number of errors for various segments of the learning and for the total relearning trials, the percentage of errorless runs for the last 15 trials of learning and the 15 trials of relearning; and the amount of savings in error scores Of these various methods of comparison, the amount of savings alone will require further amplification to be at once clear to the reader.

By means of averages and graphs based on the data of learning and relearning, it is possible to make certain group comparisons, but these comparisons are relatively crude in the absence of definite information concerning the actual amount of savings In order to get at the amount of savings from learning to relearning, it is necessary that there be some notion as to what this savings means—that is, savings to accomplish what? Owing to the fact that these groups

of animals were all run 30 trials on learning and 15 trials on relearning without reference to an arbitrary criterion of learning, it is necessary that we adopt some scheme which will show their relearning performances with reference to their respective achievements on the learning series. If, for the present data, one were to adopt a criterion of learning easy enough for the slowest group to meet, one would have the better groups reaching this criterion long before the end of the 30 trials of learning, thus introducing the factor of overlearning for the better groups. This factor would vary from group to group in such a way that no statistical device would hold it constant. A better method would seem to be one which involves the actual performance reached by a group of animals, such, for instance, as the level reached on the last six trials of learning. This will give a definite figure indicating the achievement of a particular group, and then the savings on relearning can be defined as the savings to reach this same level of performance. That is, each group will have a savings score based on its own performance just as though this performance was the errors made in reaching an arbitrary criterion of learning. As an example, if we take Group A, it will be noted in Table 4 that the mean number of errors on learning is 58.54, the mean of the last six trials is .70, and the mean number of errors on relearning to reach this level is 6.66, or a savings of 51.88 errors. Expressed as a percentage by dividing the savings in absolute errors by the number of errors on the learning, the percentage savings is 89.

If the original learning of all the groups being compared were equal, this concept of percentage saved would not be needed, absolute savings would suffice. This raises the question as to the legitimacy of making comparisons between groups which have different initial performances, and, in particular, it may be objected that the use of percentage savings is thereby invalidated. If the critical reader examines the content of Table 3, however, and relates the material therein to the percentage savings as given in Table 4, he will find that the concept of savings here used is borne out by direct comparison of those figures which do not involve division or ratios. That is, for example, if we take Groups G and L (see Tables 3 and 4), it will be noticed that L is far superior on learning, yet on relearning is inferior to G for both the whole and that part of relearning required to reach the previous level of performance. The difference in savings, 83 as compared to 58%, bears out this relationship. Or if

we consider the two groups, C and F, which have nearly the same original learning scores, we note that their relearning differs, and also that the percentage savings is again in the right direction. Thus *it is evident that this savings score gives a result which is valid for* any comparisons which we wish to make.

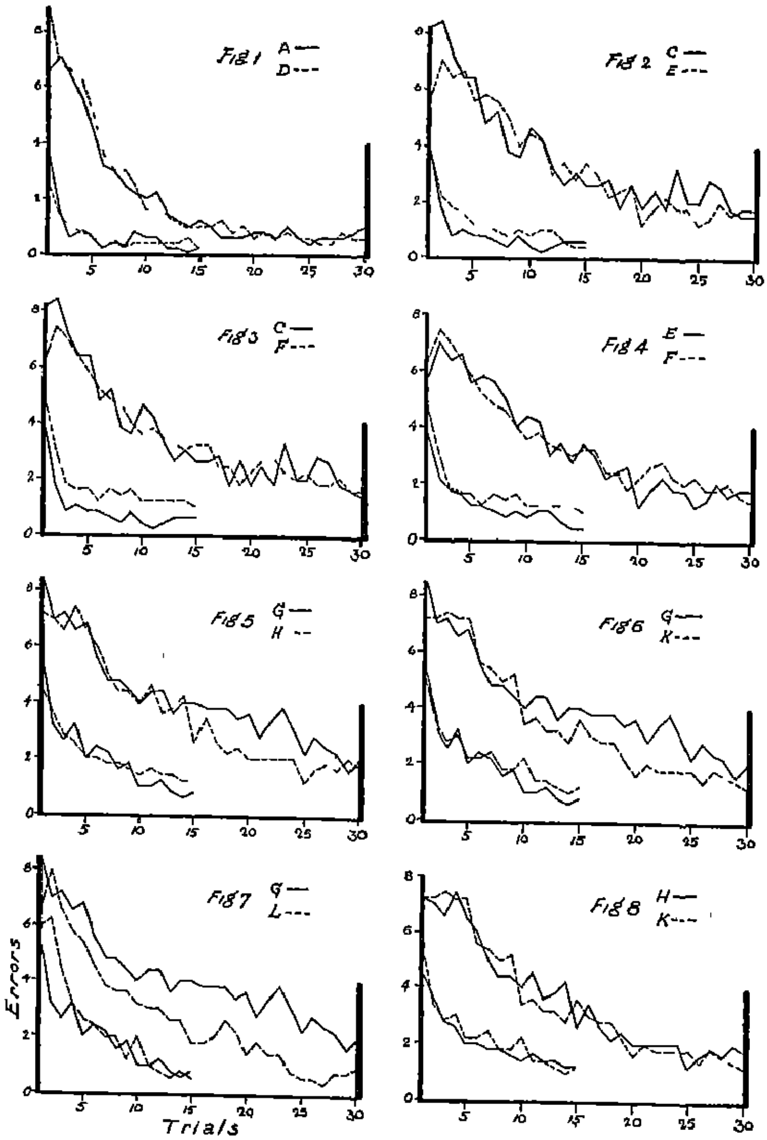
Group Comparisons

As previously stated, the 14 groups of rats, for which we are presenting data on relearning, were run under varying conditions as to age, retention interval, and laboratory experience. Wherever two of the three conditions are constant, it is possible to make *comparisons between groups.* *Thus the effect of age may be studied by* comparing groups having the same retention interval and similar experience, while with other groups it will be possible to say something regarding the effect of varying running conditions. Other groups will permit certain statements concerning the effect of differing intervals. In Tables 3 and 4 the spacing of the data indicates what groups are comparable. No other comparisons are legitimate.

TABLE 3

MEANS AND ERRORLESS RUNS FOR THE SEVERAL GROUPS

Group	N	Means on learning (1-30)	Means on learning (1-15)	Means on learning (16-30)	Means on relearning	Errorless runs L	Errorless runs R	Age
A	24	58.54±2.15	49.95	8.59	10.83±0.82	55%	62%	61
D	*31*	*63.47±2.54*	*52.75*	*10.72*	*10.52±1.00*	*60*	*62*	*116*
C	25	108.00±6.19	74.08	33.92	13.68±1.36	18	56	81
E	22	102.18±3.72	73.13	29.05	18.91±1.38	13	37	298
F	34	105.47±4.00	71.60	33.87	24.97±2.77	18	43	364
G	20	124.95±6.43	80.80	44.15	28.50±1.78	12	25	91
H	14	109.14±9.17	78.30	30.84	30.64±3.82	21	24	151
K	23	105.39±4.84	76.87	28.52	33.48±2.85	24	24	273
L	16	82.00±3.47	62.08	19.92	35.75±1.96	32	23	376
J	26	79.69±3.55	57.89	21.80	20.08±1.27	36	44	216
A	24	58.54±2.15	49.95	8.59	10.83±0.82	55	62	61
B	20	78.65±3.27	59.05	19.60	16.00±1.17	38	51	66
C	25	108.00±6.19	74.08	33.92	13.68±1.36	18	56	81
C	25	108.00±6.19	74.08	33.92	13.68±1.36	18	56	81
D	*31*	*63.47±2.54*	*52.75*	*10.72*	*10.52±1.00*	*60*	*62*	*116*
M	16	64.25±2.48	44.81	19.44	17.44±1.44	38	39	26
N	13	55.62±1.90	45.12	10.50	12.77±1.01	48	64	26
O	15	60.07±2.30	46.87	13.20	9.33±1.24	55	57	26



FIGURES 1-8
LEARNING AND RELEARNING ERROR CURVES

Group	N	Learning Mean	Learning Av last 6 trials	Relearning Errors to reach level	Age L	Age R	Percentage savings	Retent. interval
A	24	58.54	0.70	6.66	61	131	89	40
D	31	63.47	0.56	6.42	116	186	90	40
C	25	108.00	2.10	3.76	81	156	97	45
E	22	102.18	1.61	9.37	298	363	91	45
F	34	105.47	1.83	9.35	364	439	91	45
G	20	124.95	2.19	20.90	91	241	83	120
H	14	109.14	1.64	20.85	151	303	81	120
K	23	105.39	1.51	26.40	273	428	75	125
L	16	82.00	0.75	34.37	376	530	58	124
J	26	79.69	1.18	15.49	216	392	81	147
A	24	58.54	0.70	6.66	61	131	89	40
B	20	78.65	1.22	8.00	66	136	90	40
C	25	108.00	2.10	3.76	81	156	97	45
C	25	108.00	2.10	3.76	81	156	97	45
D	31	63.47	0.56	6.42	116	186	90	40
M	16	64.25	1.37	10.50	26	146	84	90
N	13	55.62	0.48	10.38	26	116	81	60
O	15	60.07	0.93	1.80	26	86	97	30

early period of the rat's life relatively small age differences will have no influence on the efficiency of relearning after a short interval. If Groups C, E, and F, which have nearly equal learning scores, are compared as to relearning, we note that C is better than either E or F, both of which are much older (see Figures 2, 3, and 4). In terms of percentage savings, we have for the three ages 156, 363, and 439 days at relearning the respective percentages: 97, 91, and 91 (see Table 4). Turning to Groups G, H, K, and L, which have a retention interval of 120 days, we find another indication of age effects. Analysis of Figures 5 to 10 and of the means of these groups in Table 3 shows that the rank order of good performance on learning is L, K, H, and G, while for relearning this order has

Age Effects Of those animals having a retention interval of 40-45 days certain groups may be compared as to age effects upon relearning. Groups A and D with an age difference of 55 days, but comparable as to training course, show no appreciable differences in error scores on relearning as evidenced by the graphs in Figure 1 and their data in Tables 3 and 4 These results suggest that in the

TABLE 4

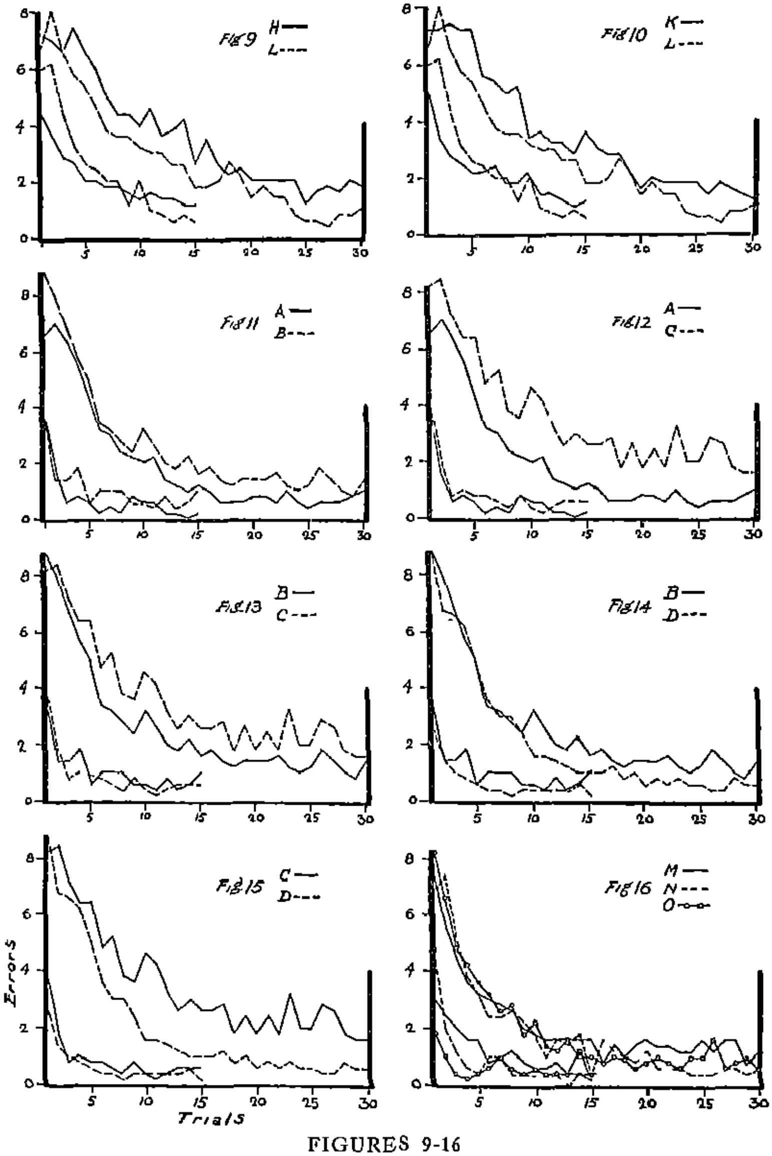
DATA ON SAVINGS FOR THE SEVERAL GROUPS

been reversed exactly. The reversal indicates that the younger groups either retain more or relearn more easily In Table 4 it will be noted that for the foregoing groups the relearning ages 241, 303, 428, and 530 days are accompanied by the following percentage savings: 83, 81, 75, and 58.

Thus it is seen from the foregoing analysis that age may be an important factor influencing the relearning ability of rats Since the retention tests involve not only retention but also learning ability, however, it may be argued that age does not affect primarily the ability of the rat to retain a habit pattern but rather affects his ability to learn There are some lines of evidence which indicate that for the ages here represented there is no noteworthy decrement in the rat's ability to form new maze habits. Following the same technique as that employed while gathering the data of this study, Stone found no appreciable reduction in ability to learn this multiple-T maze and a modified form of the Carr maze by animals parallelling the age ranges of this study (Stone, 8, pp 59, 94, 106) If Stone's results are approximately correct, it would seem reasonable to infer that the differences herein reported are due to the impairment of age on retentiveness of rats. Hence it follows that, in an attempt to study the forgetting curve or any other problem in which decrements in relearning ability are found, one should not neglect taking into account this factor of age impairment. It may be of importance to determine whether the factor of age decrement in retention may be neglected up to a certain age limit but thereafter must be taken into account

The Effects of Collateral Learning Experience on Relearning. It is a matter of interest and importance to know the effects on relearning resulting from a course of training that occurred previous, simultaneous, or subsequent to the original learning experience This subject has been touched upon by Brockbank (2), but his groups of animals were so small that only suggestive conclusions could be reached. He states that the redintegration is not impaired in rats that were required to learn to traverse a rope ladder during the retention interval. Certain of our groups with varying collateral experience may be studied from this point of view.

The learning experience of Groups A and B differ in the following respects: Group A learned and relearned the triple platform box and discrimination problem simultaneously and prior to the maze in each instance, B learned and relearned the triple platform box before



FIGURES 9-16
LEARNING AND RELEARNING ERROR CURVES

learning and relearning the maze and discrimination problem which were run simultaneously (see Table 2) As shown by Table 3, the number of errors made by Group A on its original learning is fewer than that of Group B In relearning A is proportionately better than B and the percentage savings is the same for both (see Table 4). Group D, which had the same running experience as A, bears the same relationship to B with respect to original and relearning errors as Group A and does not differ appreciably from B in percentage savings

The collateral experience of Groups A and C differ in the respect that A learned and relearned the triple platform and the discrimination problems simultaneously and prior to the maze in each instance, whereas Group C learned the maze first and then simultaneously learned the triple platform and the discrimination problems prior to relearning the maze. As shown in Tables 3 and 4, Group A shows marked superiority to C on the original learning but only slight superiority as to absolute number of errors on the relearning trials Group C surpasses A as to percentage savings The relationships of learning and relearning by these groups is graphically illustrated in Figure 12. Group D, which had the same learning experience as A, is also inferior to C as to percentage savings, although its original learning and the absolute number of errors made on relearning is lower than that of C (see Tables 3 and 4, also Figure 15)

Group B learned and relearned the triple platform box before learning and relearning the maze and discrimination problems which were run simultaneously; Group C, on the other hand, learned the maze first and then simultaneously learned the triple platform and discrimination problems prior to relearning the maze Although Group B surpasses Group C on the original learning, it is not better than C on the relearning; in fact, it is slightly poorer than C as shown by the graphs of Figure 13 and the data of Table 3. As to percentage savings, Group C clearly surpasses B.

What, one may ask, do the foregoing comparisons indicate with respect to the effects of varying collateral training? First, it may be noted that Group C, which has the least amount of preliminary training, is inferior in original learning to Group B which had, preceding its maze training, 40 trials on the triple platform box And Group B, in turn, is inferior to Groups A and D, which, in addition to the preliminary training on the triple platform box, were

also trained on the discrimination apparatus. Secondly, as to relearning, it may be noted from a consideration of Figures 11 to 15 that the mean difference in errors for these four groups on relearning is relatively small This may be due to the fact that, prior to the time of relearning, the benefits to be derived from collateral training have been approximately equalized for all of the groups Thirdly, as to percentage of savings, it should be noted that the superiority of C over A, B, and D is probably due to the fact that, on the original learning, the final level reached by C is not as low as that of the other groups. Hence, since Group C begins its relearning with only slightly more errors than the other groups, it reaches its previous level of performance in fewer trials and thus its percentage of savings is greater. On the other hand, if C were required to reach the same level as A, B, or D, more trials would be required and its percentage savings would then be about the same as those of the other groups It seems, therefore, that, as far as the above given conditions of collateral training are concerned, no general conclusions can be drawn regarding the effect of laboratory experience on retentivity

Effects of Varying Retention Intervals. Only the results of three experimental groups have a direct bearing upon the relationship between length of retention interval and the efficiency of relearning A group of 44 animals which received maze training from the ages of 26 to 55 days was subdivided into three small groups, M, N, and O, and brought back to the maze for relearning after intervals of 90, 60, and 30 days, respectively Without considering original learning scores, the animals having the first 16 numbers were put into Group M, those with the next 13 into Group N, and those with the last 15 into Group O A more satisfactory method of subdividing the original group would have been one similar to that used by Tsai (11), namely, equalizing the groups as to mean learning scores by selecting individuals for each group on the basis of their individual learning scores. Thus would have been obviated the difficulty of dealing with somewhat different final levels reached by the groups

In Table 3 are given the numerical data for these groups. Because of large individual differences and wide daily fluctuations, factors which have unpredictable effects for such small groups, the results for these three groups are not wholly consistent from method to method. It may be noted from Table 3 and Figure 16 that these

groups are nearly equal on the first 15 trials of learning, but differ sufficiently on the last 15 to make the total original learning not exactly equivalent. The percentage of errorless runs for the last 15 trials of learning is not consistent with the magnitude of the means for the same trials. On the 15 relearning trials the numbers of errors made are consistent with expectations on the basis of the differing time intervals, but again the percentage of errorless runs is not wholly consistent As to percentage savings (see Table 4), the values 84, 81, and 97 for the respective intervals of 90, 60, and 30 days are again partially inconsistent with the hypothesis that there is a direct relationship between length of interval and amount of retention These various inconsistencies would tend to indicate that the methods herein used are probably inadequate for such small samples and for short retention intervals. Therefore, we are unable to draw any definite conclusions regarding the effects of the varying retention intervals of this study

Differences in the laboratory experiences or ages of the other groups of this study make unwarranted further attempts to determine the relationship between length of retention interval and the errors made on relearning In general, however, it may be said that those groups having a retention interval of 40-45 days have greater savings than those having an interval of 120 days No conclusions concerning the so-called forgetting curve are warranted from the data at hand.

Correlation of Learning with Relearning

The question may be raised as to the consistency of the performance of the rats from learning to relearning Do the rats which are best on learning also perform best on the relearning? This may be answered by computing the coefficient of correlation between the learning and relearning scores. These coefficients are given in Table 5, in which also appear the various standard deviations. These coefficients, it will be noticed, are moderately high and consistent with the exception of those for Groups L, M, N, and O The latter three are probably low because of the small range of "ability" as is indicated by the relatively low standard deviations. The lowness of Group L is to be accounted for by the fact that two of the sixteen animals did extremely well on relearning although they were poor on learning (By removal of these two the r becomes 56). It will be noted that there is a fairly direct relationship be-

TABLE 5

Standard Deviations and Correlation Coefficients
30 Learning and 15 Relearning Trials

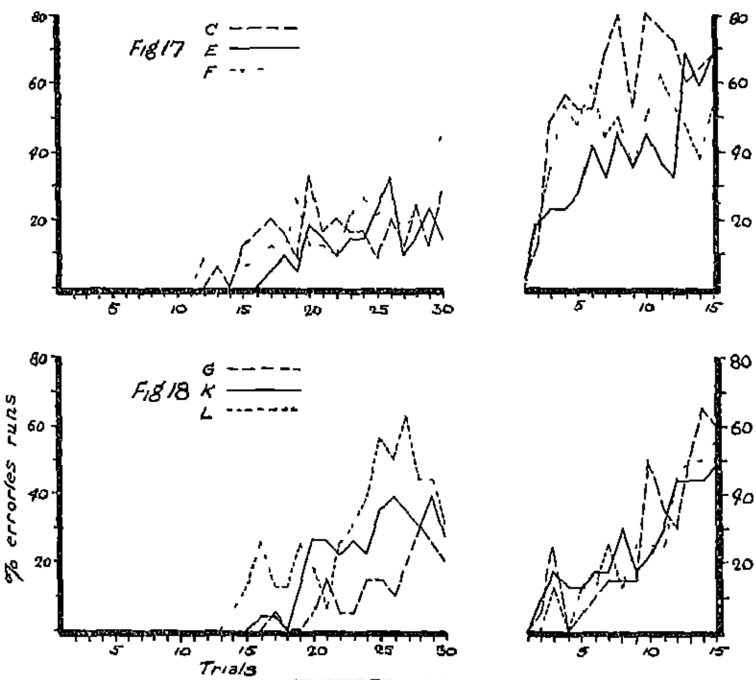
Group	N	Standard deviations Learning	Relearning	Correlation Learning vs relearning	
A	24	15.61	5.96	.628	±.083
B	20	21.71	7.80	.507	±.112
C	25	45.90	10.10	.799	±.049
D	31	20.92	8.30	.786	±.046
E	22	25.88	9.62	.656	±.082
F	34	34.98	23.98	.803	±.041
G	20	42.63	11.82	.636	±.090
H	14	50.88	21.23	.891	±.037
J	26	26.85	9.64	.722	±.065
K	23	34.42	20.27	.754	±.060
L	16	20.61	11.59	.276	±.156
M	16	14.72	8.55	—.058	±.168
N	13	10.18	5.42	.192	±.180
O	15	13.21	7.13	.012	±.174
		Best weighted average "r" =		.656	±.022

tween the magnitude of the correlation coefficients and that of the standard deviations, i.e., there is a tendency for the higher coefficients to occur where the range is greater. This finding is similar to mental test data in which case the size of the correlation is affected by the range of ability represented.

The coefficients for those animals having a retention interval of 40-45 days do not differ from those having an interval of 120 or more days. There is no difference in the coefficients associated with age differences, nor is there a difference between groups having different collateral training. Hence we may conclude that, if age, length of retention interval, or differing courses of training have any effect whatever on the correlation of learning with relearning, it does not appear in our results.

Using the method of Fisher (3, pp. 163 ff.), we have computed the mean of the coefficients in Table 5 and obtained .656±.022 as the best weighted average of the correlation coefficients between learning and relearning.

For those interested in the correlations of various segments of learning with relearning segments we have calculated and are re-



FIGURES 17-18
PERCENTAGE OF ERRORLESS RUNS ON LEARNING AND RELEARNING

porting such results in Tables 6, 7, and 8 for Groups F, J, and AD (the Groups A and D were littermate controls and differed only in the fact that D was 55 days older than A when its training began; as shown by their data of Table 3 and the graphs of Figure 1, they have almost identical learning and relearning performances; hence there is no objection to combining their data for the present use) The coefficients of Tables 7 and 8 indicate that, in general, the higher coefficients are obtained when the larger number of trials are involved, and that the shorter the segments the lower the coefficients As shown in Table 6 the coefficients for Group F are inconsistent with those of the other tables in that high coefficients are obtained for the shorter as well as the longer segments The basis of this discrepancy lies primarily in the difference in range of error scores. In Group F there were seven cases with excessively poor scores on learning and relearning and the weight of these scores

gives rise to a large covariation and high coefficients of correlation for small as well as large segments of the trial series.

A word should be said as to the interpretation we place on the correlation of learning with relearning scores, the weighted average of which is $.656 \pm .022$ It would seem that the only possible interpretation of these coefficients is one regarding the consistency of performance of animals on learning and relearning. It is not proper to regard them as coefficients of reliability, in the sense that this term is used in connection with mental tests, because in the maze

TABLE 6

GROUP F SEGMENTAL CORRELATIONS ($N=34$)

		Relearning segments					
	Trials	1-15	2-15	1-10	2-10	1-5	2-5
Learning	1-30	803	747	812	821	860	876
	6-30	810	.752	821	828	859	875
	6-20	750	696	768	773	808	.811
	1-15	693	631	722	712	776	763
	1-10	557	515	583	579	630	626
	16-30	775	731	779	.793	793	834
	21-30	774	.725	773	784	787	824

TABLE 7

GROUP J SEGMENTAL CORRELATIONS ($N=26$)

		Relearning segments					
	Trials	1-15	2-15	1-10	2-10	1-5	2-5
Learning	1-30	.722	640	597	565	417	.361
	6-30	722	.628	592	546	424	342
	6-20	711	618	594	561	454	380
	1-15	674	.598	.579	551	465	426
	1-10	666	603	.586	570	504	.490
	16-30	633	.561	498	468	276	212
	21-30	584	510	454	415	257	178

TABLE 8

GROUP AD SEGMENTAL CORRELATIONS ($N=55$)

		Relearning segments					
	Trials	1-15	2-15	1-10	2-10	1-5	2-5
Learning	1-30	731	712	705	681	684	663
	6-30	680	656	624	644	656	609
	6-20	649	611	638	618	637	582
	1-15	.614	594	596	.582	593	575
	1-10	574	583	550	567	552	596
	16-30	638	626	625	608	557	527
	21-30	514	492	494	473	449	399

situation retentivity is involved That these coefficients cannot be regarded as indicators of the relationship between learning ability and retentivity is evident if one recalls that both retentiveness and learning ability enter into relearning performance. The relative weight of these two factors cannot be determined by present analytical methods.

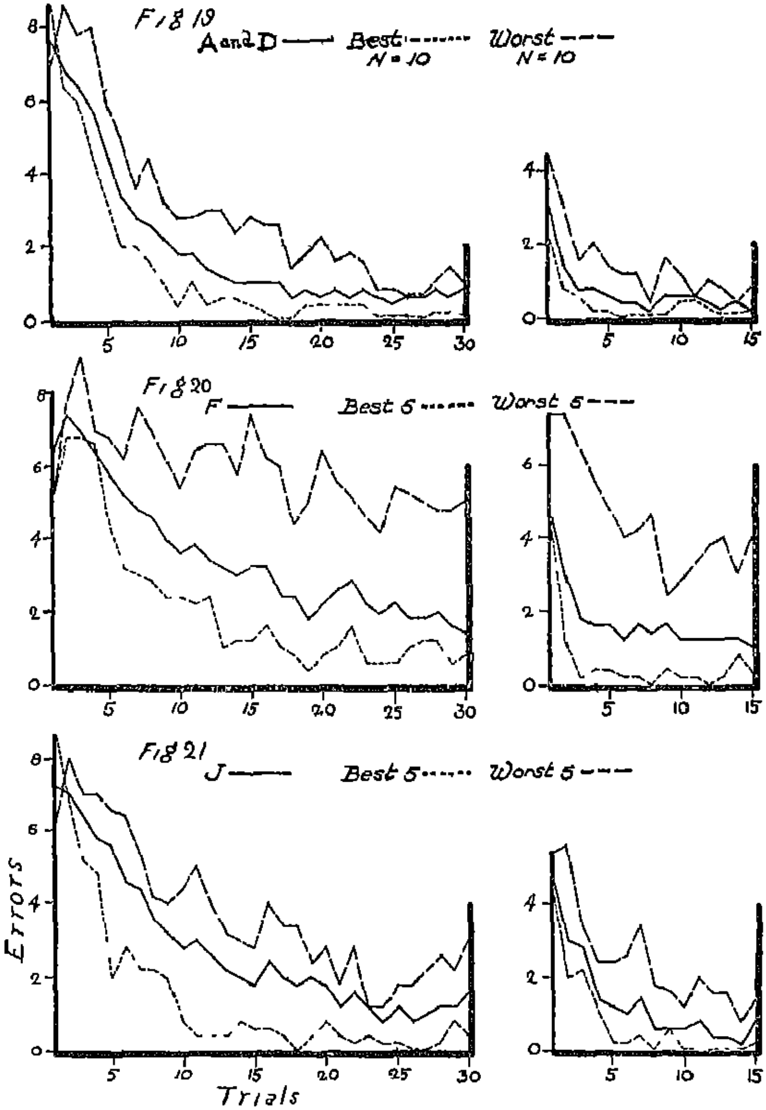
Variability of Performance

Group to group comparison of the standard deviations in Table 5 tells something concerning the relative homogeneity of the groups here studied. A comparison of the standard deviations for learning and relearning may raise an old question, namely, the effect of practice on individual differences However, as has been stated generally, the comparison of absolute deviations in data of this nature is meaningless Furthermore, since it is rather illogical to assume that we have an absolute zero, the use of the coefficient of variation in this connection could not be justified Hence we do not believe that any legitimate conclusions can be drawn from our data concerning practice effects on individual differences In connection with variability it may be of interest to know how the better animals compare with the poorer animals on relearning Figures 19, 20, and 21 show illustrative curves for the best and worst animals as compared with the curve of the average The outstanding characteristic of the best animals is that, although differing little on the first relearning trial, their curves drop much quicker than the average. The curves for the poorer animals start higher and then show a quick drop similar to that of the average. If one notes, however, the level reached on learning by the best and worst animals, and then relates their relearning performance thereto, it will be seen that the best and worst animals require about the same number of trials to reach their previous levels as required by the entire group to reach its level. This would suggest that, when relative performance is considered, the worst do as well on relearning as the average or best.

Conclusions

The foregoing data and their analysis would seem to warrant the following deductions:

1. Age as a factor seems to affect the retentivity of rats for maze habits. This effect may be independent of possible parallel effects



FIGURES 19-21

THE BEST, AVERAGE, AND THE WORST ANIMAL PERFORMANCES ON LEARNING AND RELEARNING

on the learning ability of the rat, i.e., it may be an effect on the functioning of the rat's "memory"

2 Collateral training may have an apparent effect on retention, as measured by the relationship between original and relearning scores. This effect may arise from the influence of collateral training on the original as well as the relearning trials

3 An increase in the length of the retention interval is associated with a decrease in the amount retained Our data are not sufficiently complete to permit of any statement concerning the form of the "forgetting" curve of the rat

4 The degree of consistency of individual performances from learning to relearning is indicated by coefficients of correlation averaging .656± 022 The size of the coefficients for different groups depends largely upon the range of performances represented.

5 The form of the relearning curve for errors is somewhat similar to that of original learning in these studies wherein animal groups did not completely master the maze. Under these conditions, relearning appears to be a continuation of the learning process

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ÉTUDES DE LA RÉTENTION PAR LES ANIMAUX: I NOTES SUR LE NOUVEL APPRENTISSAGE D'UN LABYRINTHE MULTIPLE-T PAR DES RATS BLANCS

(Résume)

Ce rapport consiste en notes sur la retention de 14 groupes de rats (299 individus) plutôt qu'une étude systématique du problème de la rétention L'âge sera un facteur important qui influe sur la capacité de retenir les habitudes dans le labyrinthe, surtout chez les animaux qui ont atteint ou passe au-dela de l'âge moyen Cet effet pourrait être independant des effets paralleles possibles de l'âge sur la capacité de l'apprentissage chez les rats, c'est-à-dire, il pourrait être un effet sur le fonctionnement de la "memoire" du rat Bien qu'on ait trouve que la quantité retenue a un rapport avec la longueur de l'intervalle de la rétention, on n'est arrivé à aucunes conclusions definies à l'égard de la courbe de "l'oubli" La forme de la courbe du nouvel apprentissage des erreurs ressemble quelque peu à celle du premier apprentissage dans ces etudes où les groupes des animaux n'ont pas complètement appris le labyrinthe dans la première serie Dans telles conditions, le nouvel apprentissage semble être une continuation du processus de l'apprentissage Le degré de constance des rendements individuels entre l'apprentissage et le nouvel apprentissage est indique par des coefficients de corrélation donnat en moyenne 0,656±0,022 Dans le nouvel apprentissage ainsi que dans le premier apprentissage on peut voir l'influence de l'entraînement collatéral

McNEMAR ET STONE

UNTERSUCHUNGEN ÜBER DIE BEIBEHALTUNG IM TIERGEDÄCHTNIS I BEMERKUNGEN ÜBER DAS WIEDERERLERNEN EINES MANNIGFALTIGEN T-LABYRINTHES DURCH ALBINORATTEN

(Referat)

Dieser Bericht besteht eher aus Bemerkungen über die Beibehaltung ("retention") bei 14 Rattengruppen (299 Individuen) wie aus einer systematischen Untersuchung des Problems der Beibehaltung im Allgemeinen Der Faktor des Alters übt wahrscheinlich einen wichtigen Einfluss auf die Beibehaltung von Labyrinthgewohnheiten aus, besonders bei Tieren die das mittlere Alter erreicht oder passiert haben Diese Wirkung kann von parallel einhergehenden Wirkungen des Alters auf die Lernfähigkeit der Ratte unabhängig sein, d h., sie kann eine Wirkung auf die Tätigkeit des "Gedächtnisses" der Ratte sein Obwohl ermittelt wurde, dass das Quantum des Beibehaltenen mit der Länge des Beibehaltungsintevalls ("retention interval") in Beziehung steht, wurden über die Kurve des Vergessens keine bestimmte Schlussfolgerungen gemacht Die Form der Kurve der Fehler beim Wiedererlernen gleicht etwas der Kurve des ursprünglichen Lernens in diesen Untersuchungen, worin die Tiergruppen das Labyrinth in der ursprünglichen Serie nicht ganz behersschen lernten Unter solchen Verhältnissen scheint das Wiedererlernen eine Fortsetzung des Lernprozesses zu sein. Der Grad der Übereinstimmung zwischen Lernen und Wiedererlernen bei den einzelnen Tieren wird durch Durchschnittskorrelationskoeffizienten von 656 ± 022 angedeutet Bei dem Lernen wie bei dem Wiedererlernen macht sich der Einfluss von Nebendressierung ("collateral training") bemerkbar

McNemar und Stone

THE MEMORY SPAN OF PRESCHOOL CHILDREN*

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Memory span has come to be accepted as one of the foundations of intellectual development and is rarely omitted from any battery of intelligence tests Most of the work on memory has been done on adults and school children, but very little on the preschool child In the past few years, however, psychologists have given memory tests to preschool children A brief summary of this work is given below and is grouped under the following subdivisions (*a*) digits, (*b*) syllables, (*c*) words, (*d*) tapping of cubes, (*e*) commands, (*f*) recall and recognition of pictures, (*g*) logical memory

HISTORICAL SURVEY

Digit Tests

McCaulley (25) studied the relative values of the forward audito-vocal digit memory span and the reverse span test. One thousand white and Negro children from Grades 1 to 8 were tested For five-year-old children, rated as "good" in school standing, the forward span ranged from 4 to 6 digits; for six-year-olds, from 4 to 8 digits. The reverse span was slightly lower The forward span for children rated as "poor" in school work, was from 3 to 5 digits for five-year-olds and from 2 to 6 digits for six-year-olds, with a lower reverse span in each case

Hallowell (17) studied the audito-vocal digit memory span of 657 babies ranging in age from 12 to 47 months. The results showed that "of 192 two-year-olds, only 3 gave 5 digits, 20 gave 4 digits, while 3 was the mode Even in the three year group, not until 46 months or almost the 4th birthday, do at least half of the cases give a span of 4 or more"

Town (37) tested the digit memory span of 44 children between

*Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office August 20, 1930

[1]The junior author gathered and tabulated the data for this study, the senior author assisted in planning the study, in the interpretation of its results, and in writing this report

five and six years of age Lists of 6 numbers were repeated by 4 children of this group. The average score was between 4 and 5 numbers, while the 50 percentile score was a span of 4. The auditory memory test for digits was given to 100 children whose ages ranged from two years nine months to six years eight months by Bayley (3) The results showed a large piling up of scores at 4 digits, while very few of the children could remember more than 5.

Gesell (15, pp 97-99), using a group of 50 normal children, tested at 4, 6, 9, 12, 18, 24, 36, 48, and 60 months of age, found that at four years 50% to 64% of the children remembered 4 digits, while at five years 65% to 84% passed the 4-digit test. In the 5-digit test, 1% to 19% passed at four years and 20% to 49% passed at five years.

Ide (21), testing kindergarten children ranging in age from four years to five years eleven months, found that the average auditory memory span for digits for all four- and five-year-old children of either sex was 4.

Smedley (31) found that both the auditory and visual memory span for seven-year-old children was 5 digits He found that those children with superior memory span are usually physically superior.

In a study of 120 superior children, ranging in age from three years eleven months to fourteen years nine months, Jones (22) obtained the following results

1. Auditory memory span		2 Visual memory span		3. Reverse span	
Score	Age	Score	Age	Score	Age
5	3 5	5	3.11	3	3 11
6	3.11	6	4 11	4	4 11
7	4 2	7	7 11	5	7 2
8	5 7	8	6 +	6	7 9
9	7 9	9	7 9	7	8 9
10	9.5	10	8 10		

Easby-Grave (9) tested 7500 children in 1A and 1B grades The results of this experiment showed that the frequency mode for the auditory span was 5 digits and for the visual span, 4 digits. Forty-two per cent of the children failed to give any reverse span.

Young (40), testing children from four years to ten years eleven months, found that the average forward span for four- and five-year-olds was 4 digits; for six- and seven-year-olds, 5 digits. The reverse span increased with age

Starr (33) gave the Audito-Vocal Digit Memory Span Test to 2000 children, ranging in age from four to fifteen years. At the age of four, the forward span was found to be 4 digits, and failure for the reverse span, at five years of age, the forward span was 4 digits and failure for the reverse; at six years, the forward span was 6 digits, and, again, failure for the reverse.

Humpstone (20, p. 31) found that in a distribution of first-grade children the median span for digits was 4 at the age of five years, while at the age of six 32% of the 87 cases studied had a span of 5 or more, and 1% had a span of 6, none a span of 7.

Syllables Tests

Jones (22) gave a "Sentence Span" test to 120 superior children. The number of syllables ranged from 13 to 35. A score of 13 was given by age 3 11.

Gesell (15, pp. 97-99) found that the reproduction of 3 or 4 syllables was too difficult for two-year-old children, while at three years of age, 85% to 100% pass the 6-syllables test, and at four years of age, 65% to 84% pass the 12-syllables test.

Squire (32) found that at the age of six the maximum number of syllables correctly reproduced was 10, the minimum 6, and the average, 7.8.

Carpenter (6), testing 18 six-year-old children with a series of sentences, obtained an average score of 5.3 syllables for this year group. Town (37), in an experiment with 44 children, found only 8 who could repeat sentences containing 16 words.

Words Tests

Stutsman (35) gave a word test to 529 children ranging in age from 18 to 71 months. The test was found to be of value for ages 18 to 24 months. At 24 months, 87% of the children repeated all the words.

Whipple (39, pp. 150-221) gave a memory test for abstract and concrete words. He states that "words whose meaning is understood are more easily retained and reproduced than words whose meaning is not understood."

Burt (5), using concrete and abstract words for an immediate memory test, found a correlation of +.58 between concrete and abstract memory.

Cube Tests

Baldwin and Stecher (2, pp. 106-115), applying the Knox Cube Test to preschool children, found that the age averages were less than one line correctly reproduced at two and three years of age, while at the age of four the average was 1.4 lines correctly reproduced.

Town (37) gave the Knox-Pintner Cube Test to a group of five- and six-year-old children. Of the 44 children tested, the "largest group of 13 made their chronological age score, only 4 failed to make a score corresponding to their chronological age, and 27 exceeded it from 1 to 11 years."

Pintner and Paterson (28, pp. 67-70, 136-138) gave the following standards for preschool ages: in age five, the 100 percentile was 6 lines; the 50 percentile, 2 lines; and the 10 percentile, 1 line. In age six, the 100 percentile, 8 lines; the 50 percentile, 4 lines, and the 10 percentile, 1 line.

Commands Tests

Bayley (3) used four sets of commands, ranging from one to four commands, in her "Directions Tests" given to 100 children The results of this test showed a piling up of scores at the high end, showing that the tests were not difficult enough for the group tested.

Gesell's (15) experiment on preschool children had the following results with the execution of three commissions At three years of age, 20% to 49% passed, at four years of age, 50% to 64% passed; and at five years, 65% to 84% passed

Recall and Recognition Tests

Town (37), in her testing of 40 children ranging in age from five to six years, found that the average score for recognition of pictures was 55.5 or 5 pictures, while only 4 children of the group could recognize as many as 10 pictures.

Bayley (3) used objects instead of pictures for her recognition test. Nine objects were shown to the children. The results were that "the test was simple enough so that all made some score, yet hard enough so that none made a perfect score."

Baldwin and Stecher (2, pp. 106-115) gave a Recognition Picture Memory Test to preschool children. The results showed that "almost all the children named the stimulus pictures as they looked at them, repeating the series several times A good deal of confusion was discernible, the children thinking they had just seen an object, whereas it had been presented on a previous stimulus card"

The age scores showed an average of less than one picture recognized at two years, and at 6 years, the average was 11.5

Squire (32) used a picture recall test for six-year-old children. A card 8 by 5½ inches, on which were arranged 20 pictures of unrelated objects, was exposed to each child for 30 seconds. It was found that for age six, the average number of pictures remembered was 5.3, with a maximum of 7 and a minimum of 3.

Chamberlain (7) studied the power of recall in the case of 180 children of third, fifth, and eighth grades Each child was shown 15 objects singly, and then together The child was asked to name, at the end of the experiment, all the objects he could remember. The results showed that "ability to memorize or to recall does not increase regularly with advance in age or experience."

Carpenter (6) showed a card containing pictures of 20 objects to a group of children from six to fourteen years of age. The average number recalled by six-year-olds was 5 3

Logical Memory Tests

Foster (12) studied the learning and reproduction of sensible prose material (stories) by very young children Thirty-one children ranging in age from two years seven months to four years nine months, and with IQ's of 95 to 143, were tested. Each story was read 10 times. The results showed a marked superiority of the oldest groups The correlation between chronological age and total score was + 74, and between mental age and total score, + 65. The sex difference was in favor of the boys

English and Jones (10) found that the average number of ideas recalled from a short story read to preschool children was 23.5 with an *S D* of 4.7

Aim of Investigation and Selection of Tests

The aim of this experiment was to obtain a thorough knowledge of the memory span of the child just before he enters school; to find out whether memory span tests are diagnostic of intelligence; and to discover which tests correlate highest with intelligence test scores.

The tests used were devised by the writer and were based on similar tests described by Terman (36, pp 121-323), Kuhlman (24, pp 60-182), Herring (18), and Whipple (39, pp. 150-221).

The tests used were as follows·

Auditory Memory Span Tests

1. Digits Forward
2. Syllables
3. Concrete Words
4. Abstract Words
5. Digits Backwards

Visual Memory Span Tests

6. Recall of Pictures
7. Recognition of Pictures

Kinaesthetic Test

8. Tapping of Blocks

Logical Memory Test

9. Paragraphs

Direction Test

10. Commands

In the Digits Forward Test (Test 1) there were three sets of digits, each set beginning with a series of two digits and ending with a series of seven digits. The memory span was considered to be that series of digits correctly reproduced in two out of three trials, and the score was the longest series repeated twice.

The Syllables Test (Test 2) consisted of five sentences, the first having 12 syllables, the second, 14 syllables; the third, 16 syllables; the fourth, 18 syllables, and the fifth, 20 syllables. Sample sentences were. (14 syllables) "We are having a fine time in school today, playing ball," and (20 syllables) "After playing in the snow, John went to his home, ate his dinner and read a book" The score was the maximum number of syllables correctly repeated.

The Concrete Words Test (Test 3) was made up of words selected from Gates' (14) *A Reading Vocabulary for the Primary Grades* Two sets of words, beginning with a series of two words and ending with a series of six words, were used Sample words were: Series I (*a*) orange, baby, (*c*) cup, bead, work, tree, and (*e*) grass, tree, boy, dress, light, shoe The memory span was considered to be the longest list of words correctly reproduced twice

In the Abstract Words Test (Test 4) two sets, beginning with a series of two words, and ending with a series of five words, were

used. Sample words were Series I (*a*) truth, pity, (*c*) sadness, worry, thanks, rudeness, and (*d*) pride, warmth, revenge, hardness, envy The memory span was the longest list of words correctly reproduced in the two trials

In the Digits Backwards Test (Test 5) three sets of digits were used

The Recall of Pictures Test (Test 6) was made up of pictures cut from charts in the Van Alstyne Picture Vocabulary Test (38). The child was shown three pictures, was asked to name each, and, after one of these had been removed, the child was asked to tell which picture it was The test increased in difficulty until the last test consisted of seven pictures, three of which were removed

The Recognition of Pictures Test (Test 7) was also made from the Van Alstyne Picture Vocabulary Test (38). It consisted of a series of pictures ranging in number from 3 to 7 In each part of the test, a number of pictures, equal to the original number, was added, and the child was asked to point to those pictures he had seen first The score was the maximum number of pictures recognized

The Tapping of Blocks Test (Test 8) was taken from the Pintner-Paterson Performance Test series (28) The score was the maximum number of blocks tapped in correct order

The Logical Memory Test (Test 9) consisted of two paragraphs selected from Herring's (18) *Revision of the Binet-Simon Scale*. The score was the average of the total number of ideas remembered in both paragraphs

The Commands Test (Test 10) was a modification of Test 6, Year 5, of the Terman Revision of the Binet-Simon Scale (36) There were three sets of directions The first contained 2 separate directions, the second, 3, and the third, 4 The score was either 2, 3, or 4—the maximum number of commands executed in exact order

Subjects

Twenty children enrolled in a public kindergarten of P.S. 87, Manhattan, New York City, were the subjects for this study.[2] The

[2]The writers wish to express their gratitude to Mrs. Ruth Schatteles, Principal of Public School 87, Manhattan, New York City, for allowing them to use the kindergarten group as subjects for this experiment, and to Miss Powers, teacher of the kindergarten group, for her cooperation

TABLE 1
CHRONOLOGICAL AGE, MENTAL AGE, IQ, AND TOTAL MEMORY SCORES FOR ALL SUBJECTS

Subjects	Chronological age	Mental age	I.Q.	Total memory score
1	5-8	7-10	138	60
2	5-8	6-8	118	43
3	5-10	7-2	123	50
4	5-6	6-8	121	50
5	5-5	6-2	114	48
6	5-9	5-5	94	36
7	5-4	6-2	116	48
8	5-6	7-2	130	57
9	5-3	5-2	98	36
10	5-5	6-8	123	49
11	5-5	6-3	115	45
12	5-7	5-10	104	44
13	5-6	6-0	109	49
14	5-7	6-4	113	57
15	5-6	6-2	112	46
16	5-4	5-2	97	37
17	5-10	5-8	97	43
18	5-4	7-0	131	62
19	5-7	6-8	119	53
20	4-9	5-4	112	43

group included 11 boys and 9 girls, ranging in age from four years nine months to five years ten months. The average chronological age for the group was five years six months.

For the purpose of having an objective basis of comparison within the group, each child was given the Stanford Revision of the Binet-Simon Tests. The IQ scores ranged from 94 to 138, with an average of 114 2. The mental age scores ranged from 5.2 to 7 10, with an average of 6.3. In Table 1 are given the chronological and mental ages, the IQ scores, and the total memory scores for each child.

RESULTS

The results of the Memory Span Tests were expressed in terms of average, mode, median, 25 percentile, 75 percentile, standard deviation, and probable error These computations are shown in Table 2. The various types of memory test and the correlations with each other are shown in Table 3

It is interesting to find in Table 3 a highly positive correlation be-

TABLE 2
SCORES ON MEMORY TESTS

	Test	Average	Mode	Q_1	Median	Q_3	S.D	$P.E_{av}$
1	Digits Forward	5.0	4	4.5	5.4	6.5	1.20	1.00
2	Syllables	15.1	16	14.3	16.1	16.7	1.60	1.20
3.	Concrete Words	4.3	4	4.2	4.7	5.5	.80	.65
4.	Abstract Words	3.0	3	3.2	3.5	3.8	.67	30
5.	Digits Backwards	95	0	0.0	0.0	2.6	1.20	60
6	Recall of Pictures	1.2	1	1.3	1.6	2.0	1.00	35
7	Recognition of Pictures	6.1	7	6.0	6.7	7.3	1.00	65
8	Tapping of Cubes	4.3	5	4.2	5.0	5.5	79	.65
9	Logical Memory	4.3	3 modes 7 4 2	3.0	4.5	3.0	2.08	.00
10.	Commands	3.3	1	3.2	3.7	4.2	55	50

tween all the rote memory tests. A few of the highest of these scores are given below

Digits Forward—Concrete Words $r = +.75$
Digits Forward—Abstract Words $r = +.72$
Digits Forward—Syllables $r = +.63$
Syllables —Concrete Words $r = +.70$
Syllables —Abstract Words $r = +.63$

In Table 4 are given the correlations between each test and the IQ score of the child The Logical Memory and Syllables Tests correlated highest with intelligence, with an r of .76 in the case of the first and .72 in the case of the second. The lowest correlation, —.9, was found in the case of the Digits Backwards Test.

In comparing the results given on Table 2 with those of other investigators, it was found that the scores of this experiment are a little higher than those previously reported Since the average of this group is 5.6, we can compare our results with those of five- and six-year-old children reported by other experimenters.

In sentence or syllable memory, Terman (36) places 16 to 18 syllables as average for six-year-old children The median for this test in this group was 16.1, which is high, according to Terman's standard, since the average age of the children is 5.6 years.

Terman (36) places 4 digits as standard at four years, and 5 digits at year seven The median for this group in the Digits Forward Test was 5.4 Gesell (15) says only 20% to 49% of five-year-olds pass the 5-digit test The results for this group in digits

TABLE 3

CORRELATION SCORES

(Memory Tests)

1	Digits Forward — Digits Backwards	r = —.9	P E = 03
2	Digits Forward — Syllables	r = + 63	P E = 09
3.	Digits Forward — Concrete Words	r = + 75	P E = 07
4	Digits Forward — Abstract Words	r = + 72	P E = 08
5	Digits Forward — Tapping	r = + 50	P E = 11
6	Digits Forward — Pictures Recognition	r = +.11	P E. = 15
7	Digits Forward — Commands	r = + 47	P E = .12
8.	Digits Forward — Elements of Paragraphs	r = +.54	P E = 11
9.	Digits Forward — Pictures Recall	r = + 68	P.E = 08
10	Pictures Recognition — Pictures Recall	r = + 37	P E = .13
11	Concrete Words — Abstract Words	r = +.53	P E = 11
12.	Concrete Words — Syllables	r = + 70	P.E = 08
13	Concrete Words — Tapping	r = + 47	P.E = 12
14	Concrete Words — Digits Backwards	r = — 8	P E. = 05
15	Concrete Words — Pictures Recognition	r = + 37	P E. = 13
16	Concrete Words — Commands	r = +.51	P E = 11
17	Concrete Words — Elements of Paragraphs	r = + 56	P E = 11
18.	Concrete Words — Pictures Recall	r = + 57	P E = 11
19	Syllables — Abstract Words	r = + 63	P.E = 09
20.	Syllables — Tapping	r = + 45	P E = 12
21	Syllables — Digits Backwards	r = — 6	P.E = 1
22	Syllables — Pictures Recognition	r = + 19	P E = .15
23	Syllables — Commands	r = +.63	P.E. = .09

TABLE 3 (*continued*)
CORRELATION SCORES
(Memory Tests)

24	Syllables — Paragraphs	r = + 59 P.E = 11
25	Syllables — Pictures Recall	r = + 68 P E = 09
26	Abstract Words — Tapping	r = + 52 P E = 11
27.	Abstract Words — Digits Backwards	r = —9 P.E = 03
28.	Abstract Words — Pictures Recognition	r = + 33 P E.= 13
29	Abstract Words — Commands	r = + 66 P E = 09
30.	Abstract Words — Paragraphs	r = + 57 P E = 11
31	Abstract Words — Pictures Recall	r = +.50 P E = .11
32	Tapping — Digits Backwards	r = —8 P E = 05
33.	Tapping — Pictures Recognition	r = +.29 P E = .14
34	Tapping — Commands	r = + 72 P.E = 08
35	Tapping — Paragraphs	r = +.56 P E = 11
36	Tapping — Pictures Recall	r = + 63 P.E.= 09
37	Digits Backwards — Pictures Recognition	r = —4 P E = 13
38	Digits Backwards — Commands	r = —.9 P E.= .03
39	Digits Backwards — Pictures Recall	r = — 6 P.E = 1
40.	Digits Backwards — Paragraphs	r = — 9 P E = 03
41	Pictures Recognition — Commands	r = + 39 P.E = .13
42	Pictures Recognition — Paragraphs	r = + 31 P.E = 13
43	Commands — Paragraphs	r = + 44 P E = .12
44	Commands — Pictures Recall	r = + 79 P E = .07
45	Paragraphs — Pictures Recall	r = +.54 P E = 11

TABLE 4
CORRELATION SCORES
(Memory Tests and IQ Scores)

	Tests	r	$P E._r$
1	Digits Forward	+.59	11
2	Syllables	+ 72	.08
3.	Concrete Words	+ 52	.11
4.	Abstract Words	+ 55	11
5.	Digits Backwards	—.9	.03
6	Recall of Pictures	+.61	.09
7.	Recognition	+ 42	12
8.	Tapping Cubes	+ 59	11
9	Logical Memory	+ 76	07
10	Commands	+ 64	.09

forward can therefore be considered high Terman places the ability to render three commissions as standard at year five and Gesell says 65% to 84% of the five-year-olds pass the three commissions test. The median of this group was found to be 3.7.

Those children who gave a reverse span of 3 in the Digits Backwards Test had IQ scores of 138, 123, and 121. Only three children had a reverse span of 3 The correlation between the Digits Backwards Test and IQ was negative (—.9). The Digits Backwards Test had a negative correlation with every other memory span test.

The correlation between the Digits Forward Test and the Digits Backwards Test was —9, suggesting that these two tests have nothing in common and test different abilities. There was a great difference between the median scores for the Digits Forward Test and the Digits Backwards Test. The median for Digits Forward was 5.4 and the median for digits in reverse was 0. The correlation between the forward digit test and the IQ scores was positive (+59).

Both the Syllables Test and Logical Memory Test stood very high in their correlation with IQ The coefficients of correlation were respectively +.72 and +.76 There was a positive correlation also between both abstract and concrete words with IQ scores. The coefficient of correlation for abstract words was +.55, and for concrete words +.52 The correlation between abstract and concrete words was higher than we expected it to be. It was +.53

The children did not find much difficulty in repeating the abstract words.

Recognition did not correlate as highly with all the other memory tests as did recall. The coefficients of correlation for recognition and other tests are all below .50, while the correlations between recall and the other tests are all above .50. Recognition had a greater span than recall. The median score for recognition was 6.7 and for recall, 1.6. Recall correlated higher with IQ scores than recognition. The coefficient of correlation for recall was +.61; for recognition, +.42. The coefficient of correlation between the total score and the IQ score was +.82.

Summary and Conclusions

1. The use of the Digit Backwards Test proved that the concept of reverse was much too difficult for preschool children. The task of giving digits in reverse order is beyond the ability of the preschool children used in this experiment due to the fact that it involves complete reorganization, whereas the forward span involves merely the ability to imitate. The reverse span is more complex.

2. The Digits Backwards Test could not be successfully taught to the child who did not understand it at once.

3. The Digits Backwards Test is not diagnostic of the intelligence of such young children.

4. The Digits Forward Test is highly correlated with IQ and is diagnostic of intelligence.

5. The Digits Forward Test and Digits Backwards Test differ entirely from each other and seem to test different abilities.

6. The Syllables Test and Logical Memory Test determine the child's immediate memory for ideas and meaningful material. Both correlated high with the IQ scores.

7. The memory span for lists of words is a good test of general intelligence as the correlations are positive. For abstract words the correlation is +.55; for concrete words, +.52.

8. Recall is a better test for the general ability of memory than recognition. In the Recognition Test, the stimulus is presented a second time and has to be identified. Recall requires absolute reproduction without any outside help. Recognition comes to the child more easily than does recall.

9. The Directions Test or Commands could have been more difficult in order to distribute the abilities of the brighter children

more effectively. A continuation of this test by the addition of five and six commands would be a better measure of the ability of superior children of these ages.

10. The memory span tests are highly diagnostic of intelligence. The coefficient of correlation was +.82.

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LA CAPACITÉ DE MÉMOIRE IMMÉDIATE CHEZ LES ENFANTS PRÉSCOLAIRES

(Résumé)

On a fait cette expérience dans le triple but d'obtenir une connaissance parfaite de la capacite de mémoire immédiate chez les enfants préscolaires, de savoir si les tests de cette capacité sont diagnostiques de l'intelligence, et de découvrir lesquels de ces tests ont la corrélation la plus élevée avec les résultats des tests d'intelligence.

Les tests employés ont été formulés par les auteurs et basés sur des tests semblables décrits par Terman, Kuhlman, Herring et Whipple Il y a eu des tests composés de syllabes, de chiffres progressifs, de chiffres régressifs, de mots concrets, de mots abstraits, du rappel de tableaux, de la reconnaissance de tableaux, du tapping de cubes, de paragraphes, et d'ordres.

Vingt enfants d'un jardin d'enfants municipal de la ville de New-York ont éte les sujets, dont 11 garçons et 9 filles, variant en âge de 4 ans, 9 mois, à 5 ans, 10 mois, avec un âge moyen de 5 ans, 6 mois. Le Q.I moyen a été de 114,2, et l'âge mental moyen de 6,3.

Un court résumé des résultats a donné les conclusions suivantes: le tests des chiffres régressifs est trop difficile pour les enfants de cet âge, le test des chiffres progressifs a une corrélation élevee avec le Q I ; les tests des syllabes et de memoire logique donnent tous deux une corrélation élevée avec l'intelligence, la correlation des mots abstraits avec l'intelligence a ete de 0,55, avec 0,52 pour les mots concrets et l'intelligence; le test du rappel s'est montré meilleur pour la capacité genérale de mémoire que celui de la reconnaissance, le résultat composé des tests de mémoire immédiate employés a donné une corrélation de 0,82 avec les résultats des tests d'intelligence

HURLOCK ET NEWMARK

DIE GEDACHTNISBREITE ("MEMORY SPAN") VORSCHULPFLICHTIGER KINDER

(Referat)

Dieser Versuch hatte ein dreifaches Ziel eine grundliche Kenntnis der Gedachtnisbreite ("memory span") vorschulpflichtiger Kinder zu erlangen, zu ermitteln, ob sich Intelligenz durch Prufungen der Gedachtnisbreite festellen lasst; und zu bestimmen, welche Prufungen der Gedachtnisbreite mit der Intelligenz am engsten in Zusammenhang stehen

Die von den Verfassern angewendeten Prufungen wurden von ihnen erfunden und stutzten sich auf ahnliche Prufungen von Terman, Kuhlmann, Herring, und Whipple beschrieben. Es gab Prufungen bestehend aus Silben, Zahlreien vorwarts zu sprechen, Zahlreien ruckwarts zu sprechen, konkrete Worter, abstrakte Worter, Zuruckrufung von Bildern, das Antappen von Holzklosschen [in gewisser Reienfolge], Paragraphen, und Befehle.

Als Versuchspersonen dienten 20 Kinder aus einem offentlichen Kindergarten in der Stadt New York Es waren 11 Knaben und 7 Madchen, deren Alter sich von 4 Jahre 9 Monate bis 5 Jahre 10 Monate erstreckte, mit einem Durchschnittsalter von 5 Jahren 6 Monaten Der Durchschnittsintelligenzquotient betrug 114·2 und das "geistige Alter" ("mental age") im Durchschnitt 6.3.

Eine kurze Zusammenfassung betonte folgende Ergebnisse· (1) Zahlserien

ruckwarts zu wiederholen ist fur Kinder in diesem Alter zu schwer. (2) Die Fahigkeit, Zahlserien vorwarts zu wiederholen steht mit dem Intelligenzquotient in enger Beziehung. (3) Intelligenz stand mit Gedachtnis fur abstrakte Wörter in einem Korrelationsverhaltnis von 55, und mit Gedachtnis fur konkrete Worter in einem Korrelationsverhältnis von 52. (4) Die Zuruckrufung erwies sich als Prufung der allgemeinen Gedachtnisfahigkeit besser geeignet als die Wiedererkennung (5) Die zusammengesetzte Zahl ("composite score") fur die gebrauchten Prufungen der Gedachtnisbreite stand mit den Intelligenzquotienten in einem Korrelationsverhaltnis von ,82.

HURLOCK UND NEWMARK

AN OBJECTIVE MEASURE OF EMOTIONALLY TONED ATTITUDES

From the Psychological Laboratories of Clark University

Dorothy M. Olson and Vernon Jones

Difficulty of Measuring Attitudes

Attitudes can no longer be considered to be unmeasurable The work of Thurstone (13-15), Watson (16), Chave (3, 15), Droba (4), Hart (6), Jones (7, 8), and others have indicated that it is feasible to measure attitudes reliably in cases where the subjects are sufficiently cooperative to answer truthfully various questions which are put to them But the value of a measuring instrument is greatly diminished when its validity is dependent upon the accuracy of one's observation of his own attitudes and on his veracity in reporting his observations. It is necessary, of course, to have the cooperation of the subject in any sort of examination. Even in the case of a power or speed test cooperation is required of a subject, but, once he is sufficiently cooperative to submit to the examination in these fields, he can usually be depended upon to do his best if motivation is properly handled In the measurement of attitudes, however, much more cooperation is required if the results are to be valid, for it is possible in each question for the subject to feign any attitude which he feels may be to his advantage In the present study an attempt is made to get around this difficulty by measuring attitudes through the analysis of involuntary responses where dissimulating would be impossible.

Problem

The present study represents an attempt to determine the strength of certain emotionally toned attitudes by measuring some involuntary motor responses in an association test situation The attitudes studied are those toward racial, religious, social, and economic-political questions. The predominating aims were to see if it was possible to discover without dependence upon verbal responses (*a*) differences in strengths of attitudes toward commonplace concepts and toward these controversial issues, (*b*) the relative strengths of these four problems in provoking affective responses in a given individual, and

(c) the relative standing of a group of subjects in strength of emotionally toned attitudes toward the four issues. No attempt will be made to determine the direction which the beliefs or attitudes take.

Apparatus

The apparatus used in the experiment consisted principally of a kymograph, a voice key, two sets of receiving tambours attached by an air system to needles, a metronome, and telegraph key. The subject was comfortably seated in front of the voice key (see Figure 1). This voice key was wired in series with a battery of dry cells. A contact point on a relay was wired in series with a kymograph needle and a battery of dry cells. The circuit also contained a knife-switch, which was closed at the beginning of each experimental period. When the voice key vibrated, the first circuit was broken, which permitted the contact point to close the second circuit. The closing of the second circuit caused a deviation of the kymograph needle. Thus each syllable of the verbal response of the subject was recorded as a separate mark on the kymograph paper.

Directly behind the voice key, there was a vertical board (30 cm. x 30 cm.) attached to a movable base. About 20 cm. above the base and at either side of the vertical board were attached two oval

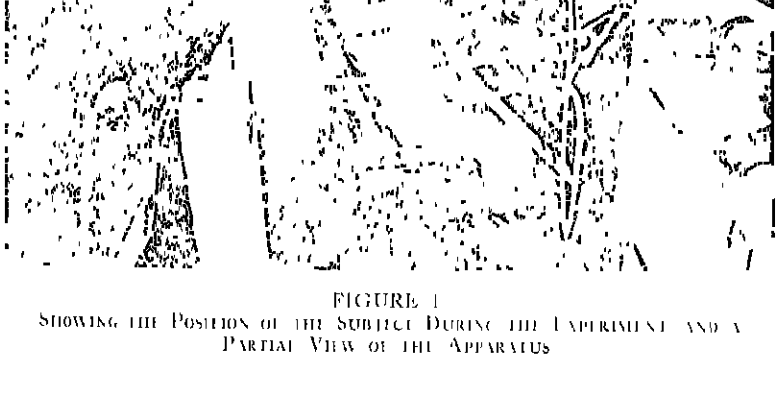

FIGURE 1
Showing the Position of the Subject During the Experiment and a Partial View of the Apparatus

receiving tambours, over which was stretched thin rubber sheeting. The subject was instructed to rest his elbows comfortably on the base and to rest the four fingers of each hand on the rubber diaphragms throughout the experiment. With the arms under the slight tension necessary to keep them in this elevated position, finer responses were presumably recorded than might be the case if the arms were at rest on the table top. The vertical board to which the diaphragms were attached was movable and could be adjusted to the arm-length of each subject. To each of the rubber diaphragms was attached a rubber tube (5mm. inside diameter and 230cm. in length), which ran to a recording tambour to which was fastened a metal needle, so that any variations of air pressure within the air chamber were recorded by means of this needle on the smoked kymograph paper.

The experimenter was seated at the table to which the kymograph was attached, and was therefore to the right of and somewhat behind the subject. The kymograph, as shown in Figure 2, was so placed that the drum was in a horizontal position. The length of the paper was 170cm. The kymograph was set at a slow speed, and the paper moved at the rate of 24cm. per minute.

A telegraph key was placed in a position convenient for the ex-

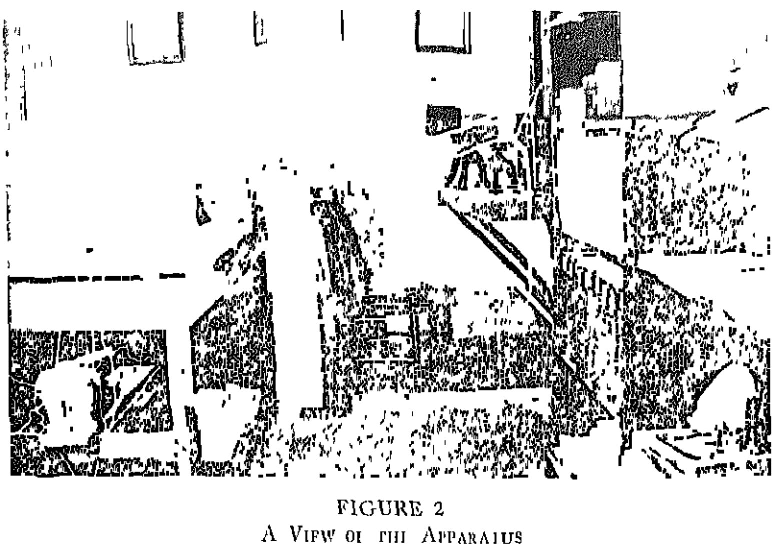

FIGURE 2
A VIEW OF THE APPARATUS

perimenter to manipulate with the left hand. The key was wired in a series with dry cells and a metal needle. Simultaneously with the giving of the stimulus word, the experimenter pressed down on this key which broke the contact and was recorded as a deviation in the line on the smoked sheet. In addition to the stimulus key operated by the experimenter, there were also at the experimenter's left two switches. One, a double knife-switch previously referred to, controlled the two circuits which connected voice key and voice needle. The other controlled the time line which was marked off by a needle wired in series with a metronome placed in a sound-proof box located in an adjoining closet. The metronome was adjusted to close the circuit once every second.

The five needles which traced on the kymograph paper have now been described. As shown in the accompanying sample record (Figure 3), the lowest needle marked off the time in seconds, the second recorded the time the experimenter called out the stimulus word, the third recorded the time the response word was given by the subject. The fourth and fifth needles recorded any variations in the pressure of the fingers of the subject's right and left hands, respectively, upon the rubber diaphragm. These variations manifested

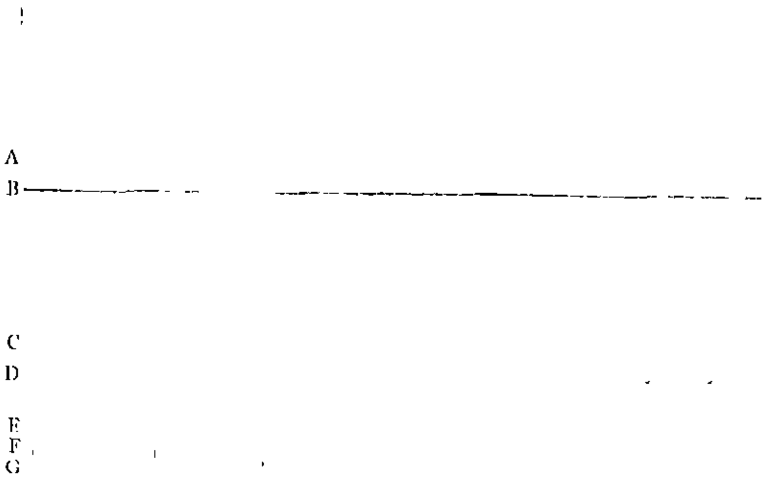

FIGURE 3

SECTION OF A KYMOGRAPH RECORD SHOWING MOTOR RESPONSES, TIME OF VERBAL RESPONSES, TIME OF WORD STIMULI, AND TIME LINE

A—Right-hand response. *B*—Base line. *C*—Left-hand response. *D*—Base line. *E*—Voice response. *F*—Stimulus. *G*—Time line.

themselves on the kymograph record in the form of runs of two types: small runs which occurred between the stimulus and the response, which we shall refer to as the preliminary response, and the larger movements which the subject made simultaneously with the verbal response according to the instructions given. The latter we shall refer to as the main response.

Subjects Used

Sixty-one college students were used as subjects, 55 of whom were men and 6 were women. Each of these was given the test individually. So far as college training was concerned, the group was constituted as follows: 7 college freshmen, 5 sophomores, 8 juniors, 33 seniors, and 8 graduate students. Intelligence test scores[1] were available for only those students who were below the senior class level. The mean percentile score for this group was .647, with a standard deviation of .227. The range was from .108 to .926. We may conclude, therefore, that our group, or at least that portion which was tested, was somewhat above the average of the general undergraduate college population of the country. The range, however, was wide. It was not feasible to make a study of the cultural background of the subjects, but it was the unanimous opinion of all members of the faculty consulted that the background of our group was below the average of the college students for the country-at-large, but again the range was wide.

Nature of the Test

The device used to stimulate emotionally toned responses was the giving, in rather rapid-fire manner, of words and brief sentences bearing on four issues concerning which prejudices are presumably strong. Altogether there were 66 words and 14 sentences. In the case of the words, each subject was directed to respond with the first word which he thought of; in the case of the sentences he was directed to say "yes" or "no" to each statement, indicating agreement or disagreement. These verbal responses were taken in order to distract the attention of the subject from certain motor responses which we wished to measure; however, nothing depends upon these verbal responses, as will be shown later.

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[1]The intelligence test used was the Psychological Examination for College Entrants devised by L. L. Thurstone and published by the American Council on Education, Washington, D. C. The standard percentile scores were based upon the scores of approximately 35,000 college freshmen.

Ten words bore on religious issues and were selected with a view to stirring up in the individual an emotional response if he had any strong bias in one direction or another on this issue The words in the test which were designed to do this were numbers 5, 6, 20, 21, 26, 27, 41, 42, 62, and 63 The sentences designed to do the same thing were numbers 4 and 5 Six words were designed to reveal racial prejudices; they were numbers 14, 15, 35, 36, 53, and 54. The sentences bearing on this issue were numbers 1 and 2 Fourteen words and two sentences bore on such controversial issues in the field of social relations as marriage, prohibition, and law enforcement, they were words 8, 9, 11, 12, 17, 18, 32, 33, 38, 39, 56, 57, 59, 60, and sentences 7 and 8 Fourteen words and two sentences dealt with controversial issues in the economic-political field, these were words 2, 3, 23, 24, 29, 30, 44, 45, 47, 48, 50, 51, 65, and 66, and sentences 13 and 14.

The remainder of the words, 22 in number, were included as control words So far as could be determined these words bore upon no controversial issue They were selected from the Kent-Rosanoff list because of the low frequency with which unusual individual responses were given to them in the free association test In addition to the words, there were also four sentences used for controls.

The grouping of the words into the four categories was of necessity done somewhat arbitrarily Most of the words fell definitely into one of the four divisions, but a few of them gave trouble in that they might have been classified in either of two lists. There was at least one word in the "racial" category which might have been grouped in the "religious" list, and there were one or two words in the "social relations" category which might have been placed in the "economic-political" list, and vice versa The final placement of such words was determined on the basis of majority judgments of graduate students in the fields of history, economics, and sociology.

Table 1 gives the entire list of stimulus words and sentences. The words and sentences are given in the order in which they were dictated to the subjects The words and sentences in plain type are the control stimuli, those in italics are designed to call out emotionally toned responses

Directions to the Subject

The subjects were at no time informed as to the exact purpose of

TABLE 1

WORDS AND SENTENCES USED AS STIMULI FOR THE VERBAL AND THE MOTOR RESPONSES

1	Table	23	*Communism*	45	*Capitalist*
2	*Bolshevist*	24	*Radical*	46	Hammer
3	*Soviet*	25	City	47	*War*
4	Mountain	26	*Preaching*	48	*Militarism*
5	*Roman Catholic*	27	*Moralizing*	49	Hand
6	*Pope*	28	Whistle	50	*Socialist*
7	House	29	*Big business*	51	*Rotarian*
8	*Free love*	30	*Wall Street*	52	Wild
9	*Birth control*	31	Blossom	53	*"Nigger"*
10	Chair	32	*Companionate marriage*	54	*Ku Klux Klan*
11	*Labor union*	33	*Divorce*	55	Head
12	*Child labor*	34	Foot	56	*Censorship*
13	Fruit	35	*Jew*	57	*Prohibition*
14	*Negro*	36	*Synagogue*	58	Stove
15	*Lynching*	37	Window	59	*Social service*
16	Carpet	38	*Capital punishment*	60	*Minimum wage law*
17	*Woman suffrage*	39	*Prison reform*	61	Cottage
18	*Feminist*	40	River	62	*Catholicism*
19	Lamp	41	*Fundamentalist*	63	*Vatican City*
20	*Religious revival*	42	*Immortality*	64	Light
21	*Miracles*	43	Needle	65	*Pacifist*
22	Bread	44	*Landlord*	66	*Peace movements*

1. *Negroes are shiftless, lazy, and lawless*
2. *The Ku Klux Klan is an undesirable organization.*
3. Babe Ruth is a famous baseball player
4. *All religious beliefs are unscientific.*
5. *Roman Catholics are superstitious*
6. Commander Byrd flew to the South Pole.
7. *Women should accept the "double standard" in morals.*
8. *Women are unable to compete intellectually with men*
9. The Naval Conference was held in England
10. *Jews take advantage of a man in business*
11. *Jews make most desirable citizens*
12. Lindbergh is a well-known football star
13. *The government should control all industry*
14. *We should recognize Soviet Russia.*

the experiment. The instructions were uniform for each subject. After a brief preliminary statement, the subject entered the experimental room with the experimenter. The subject was seated in a chair in front of the voice key, and was instructed as follows:

> "Please rest your elbows comfortably on the shelf, and rest the four fingers of each hand on the rubber disks."

The experimenter made sure that the subject was in a good comfortable position, that his elbows were resting on the table, and that the fingers of each hand, not including the thumb, were resting lightly on the rubber disks.

The following directions were then given to the subject:

> "I am going to call off a series of words to you. As I call each word, I want you to respond with the first word you can think of. For example, if I should say 'chair,' you might respond with 'table'; if I should say 'book' you might say 'paper.' Throughout the experiment, your fingers must continue to rest on these rubber disks and must always be in contact with them. However, as you speak your word response into the voice key, I want you to press down quickly with both hands on the rubber disks. After pressing down, be sure your fingers always remain in contact with the rubber."

Before the regular test began, ten preliminary words were given by way of practice. The preliminary words were chair, floor, book, paper, sky, hill, door, roof, glass, and pencil.

The 66 test words were then called out by the experimenter in a clear voice, but without any special emphasis on any particular words. As each word was called out, the experimenter pressed the telegraph key which registered on the kymograph record the time when the stimulus word was given.

After the words were completed, the experimenter gave the following directions:

> "I am going to read to you a series of sentences. If you agree with the statement made in the sentence, say 'yes.' If you disagree, say 'no.' At the same time that you make your response to each sentence, press down on the rubber disks just as you did for the words."

The fourteen sentences were then called off.

Before leaving the experimental room, the subject was asked not to reveal anything of the nature of the experiment to other students. The students were very cooperative, and it is believed that they at-

tempted to follow this suggestion. Judging from the attitudes and questions of subjects when they appeared for the examination, it seemed that they knew little or nothing about the apparatus or the words used in the test. As a further control, no mention was ever made of the word "prejudice" during the experiment. No one besides the experimenters knew until all the observations had been taken that the experimental words were designed to fit into the four controversial categories of race, religion, social relations, and economics-politics.

Quantitative Measurements of Kymograph Records

Since the aim of this study was to see what progress could be made in measuring attitudes without dependence on the verbal responses of subjects, no particular interest was taken in the verbal responses, though they were taken down as a matter of record. The main interest was centered on the motor responses which were registered on the kymograph records. Even a casual glance at the records showed that there were, in general, qualitative differences between the runs for the control and for the experimental words. Luria (10), in his study of criminals, had found that, and he was content to rest his case on the assertion that such qualitative differences would always be found. In criminals and psychopathic cases where extremely strong responses are made to certain concepts, it may be possible in every case to identify clearly the experimental word. But in the present study any dependence upon qualitative differences would have opened the way to much guess work. It was decided to make numerical measurements of the runs on the kymograph records so that they might be handled statistically. There were two important measurements to be made in connection with the motor responses to each stimulus word or sentence: first, the measurement of the height of the main excursion registered when the verbal and motor responses were made simultaneously, and, secondly, the measurement of the runs which appeared before the final response was given.

The main responses were measured to the nearest millimeter by means of Vernier calipers. The distance measured was the total height of the run of the needle above the level at which it was registering when the stimulus word was given. In Figure 4, for example, the distance OR is taken to be the height of the main motor response for the first stimulus word and $O'R'$ for the second.

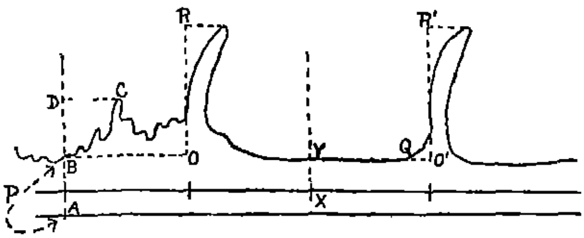

FIGURE 4

A DIAGRAM ILLUSTRATING THE METHOD OF MEASURING THE PRELIMINARY RESPONSES

P=point at which stimulus was given

Measurements of these main responses were tried but given up because, from a study of the results on two-thirds of the cases, it was found that no significant differences were being obtained between the control and the experimental words. This finding agrees with the qualitative observation of Luria (10) to the effect that it is not the main responses which are significant for the discovery of the affectivity of the subject, but rather the preliminary responses [2]

The second measurement which was made was that of the tallest run preliminary to each main run. This measurement is illustrated diagrammatically in Figure 4 The distance DB is the length of the longest preliminary run for the stimulus word given at A There was no preliminary run (i.e., preliminary run of 0) for the stimulus word given at X These preliminary responses were measured in this manner for all the words and sentences of all the subjects Separate measures were made, of course, for right-hand and left-hand responses Vernier calipers were used in making the measurements, and the results were reported to the nearest millimeter. By means of these measurements it was possible to translate these runs on the kymograph record into quantitative form so that they could be treated statistically

[2]In connection with the measurements of these main responses, it should be said, however, that while we find no evidence that any significance can be attached to the mere height of these main runs, it is still possible that the area described by the main run, especially if combined with the preliminary runs, would be significant Indeed, it is not improbable that a measure of the total length of the curved line from the point where one stimulus word was given to the point where the next word was given would represent the best possible evaluation of these motor responses.

Pressey X-O Test

The Pressey X-O Test for Investigating the Emotions (11) was given to 38 of the subjects The 38 cases were selected out of the total group of 61 on the basis of convenience of classroom testing, these students constituting two entire undergraduate classes, one in Education and the other in Educational Psychology It was not feasible to test the other students.

Ratings and Rankings by the Subjects

After the testing was completed, each of the subjects was asked to rank the following types of problems in order of their potency for arousing in himself emotionally toned attitudes: questions of religion, questions of race, questions of social relations, and questions of economic and political nature. The four categories to be ranked were made specific by the giving of several illustrative words in connection with each. In order to encourage frankness in these rankings, emphasis was placed first upon the fact that the experimenters were not concerned about what their attitudes were but only about the strength of them, and, secondly, upon the fact that the experimenters were not concerned even about the strength of individual attitudes except as they supplied reliable data for this statistical study. A system of identification numbers was employed instead of names.

After this self-rating was done, the subjects were asked to rate each other They were assured that these ratings would be kept strictly confidential, and no names were signed to the rating sheets. Since the college from which these subjects were taken was small, numbering 252 undergraduate students, and since the majority of the men were upperclassmen, it was believed that each man would be well acquainted with at least 8 or 10 men of the group tested. One whole fraternity consisting of 18 men cooperated The subjects were given a list of names of all who cooperated in the experiment, and they were directed, first, to pick out the one person whom they considered to have the most strongly emotionally toned opinions on economic-political problems and place his name at the top of the list for such problems. They were instructed to do the same for each of the other three issues. The raters were free to place the same name at the top of more than one list if they desired to do so. Next they were asked to go through the list of names and select six

TABLE 2

COMPARISON BETWEEN RESPONSES TO EXPERIMENTAL AND CONTROL STIMULI

Facts for the experimental words given for the four categories separately and for the total Entries refer to heights of preliminary runs (in millimeters)

		Range	Height of runs Mean	$S.D_{dis}$	No of subjects	No of responses (No cases x stimuli)	Diff (exp minus control)	Differences $S.D_{diff}$*	$\frac{Diff}{S D_{diff}}$†
1	Control words and sentences	0-14 4	2 55	2 38	61	1708			
2	Total experimental words and sentences	03-14 4	4 36	3 45	61	3172	1 81	173	10 45
3	Religious	0-22 6	4 38	4 40	61	732	1 83	432	4 32
4	Racial	0-17 6	4 09	3 75	61	488	1 54	332	4 60
5	Social	0-15 3	4 74	4 11	61	976	2 19	406	5 39
6	Economic-political	3-18 5	3 99	3 49	61	976	1 44	411	3 50

*$S.D_{diff}$ was computed by the following formula

$$\sigma_{diff} = \sqrt{\sigma_{M_X} + \sigma_{M_Y} - 2r_{XY}\sigma_{M_X}\sigma_{M_Y}}$$ See Kelley (9, pp 182-184).

The r's based on the correlations of the control words with the experimental words, and with each of the four categories were respectively 72, 65, 72, 64, and 45

†If $\frac{Diff}{S.D_{diff}}$ is greater than 3, the differences are considered statistically reliable

men whom they knew best, not including those whose names had already been put at the top of the lists The men of the fraternity which was cooperating were asked to select fraternity brothers. The raters were then asked to rank these six men in order on the basis of the strength of their emotionally toned opinions toward economic-political questions, and then to rank the same six on social issues, and then on racial issues, and, finally, on religious issues.

Results

Differences between Responses to Experimental and Control Stimuli. One of the first problems which arise in connection with this method of attack in the measurement of attitudes is the success with which these motor responses serve to differentiate between the experimental and the control stimuli If the technique is measuring anything, it seems obvious that it should yield different results for these two. Table 2 gives the comparison between the responses on the control words and sentences and the experimental words and sentences, both for totals and for separate categories The table shows clearly that the responses to the experimental words and sentences are stronger than those to the control.

The average difference between the total experimental words and sentences and the control words and sentences is 1 81 millimeters. This difference is significant statistically as is indicated by the ratio of the difference to the standard deviation of the difference, which is in this case 10 45 to 1. If this ratio were 3 to 1, the chances of this difference becoming zero would be only 27 out of 10,000; with a ratio of 10 45 to 1 the chance of this difference being due to chance errors is infinitesimal. Not only is this difference between the totals significant, but also the difference between the control group and each of the separate groups is significant. It is interesting to note that the greatest difference was obtained between the control words and the words in the social relations category This tends to indicate that the subjects examined in this study reacted more strongly to verbal stimuli involving questions of social relations than to stimuli involving questions of race, religion, or economics and politics It seems probable that a factor contributing toward the strength of reactions in this category is youth's general affectivity toward questions of sex The difference here may not mean so much a matter of stronger attitude toward one side or the other of the

issues in the field of social relations as it is a matter of strong emotional response to any questions directly or indirectly relating to sex. Since we are concerned here with the discovery of issues which touch "affectivity spots" in the individual and not with the analysis of the reasons behind such sensitivity, we have not attempted to discover how much of the total response was due to emotionally toned attitudes toward this or that method of control and how much was due to attitudes toward the thing controlled.

The responses to religious issues were the next strongest after those in the field of social relations, then followed racial questions, and, lastly, economic-political questions.

Reliability of the Test Measures. In attempting to discover how reliably the test was measuring whatever it was measuring, a correlation was computed between the results yielded by two halves of the test. That is, the total score or words 2+6+8+12 . . . + sentences 2+4+8 . . . minus ½ the sum of the control words was correlated against the total score based on words 3+5+9+11. . . + sentences 1+5+7 . . . minus ½ the sum of the control words. This correlation was found to be .609±.068. This is the reliability coefficient for one-half of the test; the reliability of the whole test, as computed by the Spearman-Brown prophecy formula, is .757. The reliability coefficient for each separate category was also computed. All the facts are given in Table 3.

Relation between Emotionally Toned Attitudes and General Affectivity. As was stated earlier, the Pressey X-O Test was given to 38 of the subjects chosen at random. On the bases of this test affectivity scores were worked out. For these same subjects difference scores were obtained on our data by subtracting the preliminary responses on the control words and sentences from the preliminary responses on the experimental words and sentences. The latter scores represented the degree to which the subjects were disturbed by the words and sentences on these controversial issues, the former represented measures of general emotionality. The correlation between these two was computed by the Pearson product-moment method, and found to be .29 with a *P.E.*$_r$ of .10. This correlation is not unlike the correlation found for the same subjects between Pressey Affectivity Scores and Watson (16) Crude Prejudice Scores, the r in this case being .38±.09.

Comparison between Test Measures of Subjects and Ratings of

TABLE 3
RELIABILITY COEFFICIENTS AND RELEVANT VARIABILITY MEASURES

	Composed of	$r_{\frac{11}{22}}$	$P.E._r$	No cases	r_I	σ_1	$\sigma_1\sqrt{1-r_I}$
Whole test	44 words and 8 sentences	609	068	40	757	84 75	41 78
Religious category	10 words and 2 sentences	579	071	40	733	25.85	13 36
Economic-political category	14 words and 2 sentences	.535	076	40	697	35 60	19 58
Social relations category	14 words and 2 sentences	265	090	40	419	36 45	27 77
Racial category	6 words and 2 sentences	244	100	40	392	15 55	12 13

Them by Fellow-Students As has been explained previously, the subjects were asked to rank in order eight or ten of their fellows in each of the four categories From the data thus obtained it was possible to calculate the average position of each subject on the four categories separately and on the total In obtaining the average rank a score of 8 was arbitrarily given to a rank of 1, 6 to a rank of 2, 5 to 3, and so on down to 1 for a rank of 7. The number of times which the median man was ranked by his fellows was 14. The range was wide, one man being ranked 61 times and 4 not being ranked at all. Q_1 was 8, and Q_3 was 25

In order to determine what agreement existed between the test results and these ratings, a correlation was computed between these two measures for each of the four categories separately and for the total The correlations are given in Table 4.

TABLE 4

CORRELATION BETWEEN TEST MEASURES OF SUBJECT AND RATINGS ASSIGNED BY FELLOW-STUDENTS

Facts are given separately for each category and for the total Coefficients computed by Pearson product-moment method

Students' ranks vs test results for	No of students	r	$P E._r$
Religious issues	51	— 12	093
Racial issues	54	+.06	092
Issues in social relations	52	+.25	087
Economic-political issues	52	— 14	.092
Total	55	+ 09	092

The striking fact disclosed by this table is the very low correlations existing between students' ratings and the test results The only place where there is even noticeable positive relationship is in connection with questions of social relations, and this is not large.[8] One of three interpretations seems possible in connection with these low correlations either the test is not ranking the subjects correctly, or else the students are not ranking their fellows correctly, or else both of these measures contain errors. It is believed that the third interpretation is the proper one The fact that the correlation on social relations is appreciably higher than any of the others proba-

[8]It is interesting that it was in connection with this same category that the largest differences were found between experimental and control words

bly means that the students "air" their opinions on such issues as free love, divorce, feminism, and prohibition more often and more freely than on issues of race, religion, or economics and politics. If such were the case, the student ratings of one another would be most accurate within this category of social relations Another observation which leads us to believe that the students' ratings were not an accurate criterion against which to correlate our measures is the probability that any man who showed tendencies toward leadership and who was well known was more likely to have made his opinions known and therefore more likely to have been ranked higher on the scale of emotionally toned attitudes than a quiet man who kept his opinions to himself A third reason for concluding that there were errors in the students' rankings was the large variability in ranks assigned to a given man. A fourth reason is that the highest 10% could not be distinguished from the lowest 10% by means of the Prejudice Scores on the Watson Test of Fair-mindedness Of course the argument that the students' rankings contain errors, which would tend to force correlations with another measure toward zero, does not prove that the other measure is accurate[4] However, it does indicate that even if the test measures were fairly accurate the correlations between them and a set of inaccurate measures would be very low Since the test method served to distinguish between the control words and experimental words, and since the correlation between test results and student rankings is .25 in that category where the students are probably most capable of judging their fellows, it seems defensible to conclude not that our test results have high validity but that they probably have higher validity than the average correlation in Table 3 would indicate. This conclusion will be substantiated by the results from a second method of testing for validity which will follow.

Comparison between Test Measures and Self-Ratings It has already been explained (p. 184) that each subject rated himself by

[4]Of course the most serious source of inaccuracy in the test measures—and a type of inaccuracy which could not be eliminated by lengthening the test and making the stimulus words stronger—is the fact that the height of the preliminary runs may be to some extent characteristic of individuals and not perfectly correlated with the intensity of the affective tone If this should be found in future research to be the case, the method, though invalid for ranking individuals toward certain issues, might still be used to determine the relative potency of various issues upon the individual

indicating the relative strength of the four categories in calling out in himself strong emotionally toned opinions. That category which contained words and sentences which, in the subject's judgment, elicited in him the strongest responses was given a rank of 1, the one which was next in potency was ranked 2, the next was ranked 3, and the weakest was ranked 4 It was also possible from our records to determine the relative strength of the four categories for each individual This was done by totaling for each subject the preliminary hand responses for the words and sentences in each category, and then ranking the categories in the order of height of the various totals. Thus on each category we have two ratings for each individual. the self-rating and the test rating It is, therefore, possible to study the relationship between these two ratings for each

TABLE 5

RELATIONSHIP BETWEEN TEST RANKING AND SELF-RANKING OF THE CATEGORIES

Coefficients determined for the four categories separately by the method of mean square contingency*

No of cases	Coefficients by categories				
	Religious	Racial	Social relations	Economic-political	Plain average
45	50	33	44	66	48

*The maximum value of a coefficient of mean square contingency for a 4 x 4 table is 86. See Yule (18, p 66) It should be noted in this particular problem that a constricting influence is being exerted by the coefficient in one of these categories upon the coefficients in the others For example, if racial issues are ranked 1 by the test for a given individual and this same issue is ranked 1 by the individual himself in his self-rating, there appears not only perfect agreement in this one category, but the relationship in each of the other categories is helped also because there remains only the ranks of 2, 3, and 4 in each of the variables to be matched up In this case, if a chance factor operated to account wholly or in part for the perfect agreement on racial issues, it would also operate through this constricting influence to boost the coefficients in the other three categories But, of course, a chance factor which accounted wholly or in part for disagreement between the ranks for a given category would operate to lower the coefficients in the other three categories Chance errors would, therefore, be just as likely to lower the coefficients as to raise them In a large number of cases the chance errors would cancel out, and therefore the general level of the coefficients represented by the average would not be spurious

The number of cases in this table is less than that for the former ones due to the fact that no attempt was made to force a subject to do the rating if he showed hesitancy in doing so. Some of the students who did not do the rating argued that they did not feel that they could do it at all accurately, others were apparently unwilling to divulge their own attitudes

category by using the coefficient of mean square contingency. For example, if the subject in rating himself thought that his emotionally toned attitudes were stronger for religious issues than for any of the other three, he would rank issues in this category as 1, and the other categories would be ranked after this in their proper order. On the basis of the test results, another rank, say 3, might be assigned to this category for this individual Thus for each individual there were two ratings for each category. Four separate coefficients of contingency were computed · one for each of the categories. Table 5 gives the coefficients obtained.

The coefficients indicate that the ranks assigned to each of the four categories by individuals in rating themselves and the ranks assigned by the test are in much closer agreement than could be accounted for by chance. It is interesting to compare these coefficients with a series computed between self-ratings and ratings by fellow students. The category rankings as given for each man by his fellow students were computed by ranking the average ranks in the four categories. For example, student G received an average rank of 4 on religious problems (number of raters = 8); an average rank of 2.5 on racial problems (number of raters = 11); an average rank of 3 8 on problems of social relations (number of raters = 16); and an average rank of 5 1 on problems of an economic-political nature (number of raters=14). The category rankings for this student would be: economic-political issues with a rank of 1; religious issues with a rank of 2, issues in social relations with a rank of 3, and issues involving race with a rank of 4. The relation between such ranks and self-ranks was compared, and the coefficients given in Table 6 were obtained.

TABLE 6

RELATIONSHIPS BETWEEN SELF-RANKING OF CATEGORIES AND FELLOW-STUDENT RANKING OF CATEGORIES

Coefficients determined for the four categories separately by the method of mean square contingency.

	No of cases	Coefficients by categories				
		Religious	Racial	Social relation	Economic-political	Plain average
Self-ranking vs. fellow-student ranking	36	.55	43	44	.58	50

By comparing the coefficients in Tables 5 and 6, it will be seen that the agreement between the 9-minute test and the self-ratings was, on the average, almost identical with the agreement between fellow-ratings and self-ratings. This means that, if we use the men's self-ratings as the criterion,[5] we can learn as much about the relative strength of college men's attitudes toward these four issues grouped in these four categories by means of the 9-minute test as their college friends learn about them during several years of association. It is admitted that the criterion measure does not have perfect reliability[6] However, the coefficients between the test ratings and self-ratings and between fellow-ratings and self-ratings would be equally influenced by low reliability in the criterion; therefore the comparison between the test results and the fellow-ratings on the basis of the agreement of each with the criterion would be valid

Summary and Conclusions

1 A series of words and sentences bearing upon four controversial issues was arranged for college students with a view to stimulating responses which would reveal emotionally toned attitudes toward these issues The issues studied fell under the general headings of religion, race, social relations, and economics and politics Words and sentences on non-controversial issues were given as controls The method used in an attempt to record and measure these responses was an adaptation and extension of the *Ausdrucksmethode* employed by Luria in his investigation of criminals in Russia. The method consists of recording on a kymograph record the tremors and other responses of both hands preceding and accompanying the

[5]If we use the ranks of fellow students as the criterion, we find an average coefficient of mean square contingency of 42 (out of a possible 86) between it and the test ranks.

[6]Twenty-one of the men were asked to rank the issues a second time, a month having elapsed since the first ranking In 7 cases identical ranks were given to all four categories, in 10 cases two of the categories were given a different rank in the second case, in 2 cases three of the categories were given a different rank, and in 2 cases all four categories received a rank different from the one assigned in the first ranking From these facts it is obvious that the reliability of the criterion was much below 1 00, and consequently the agreement between our scores and this fallible criterion was lower than the agreement which would have been found if we had been working with a reliable criterion. See Kelley (9, pp 200-201) for a discussion of this as applied to problems involving coefficients of correlation.

verbal responses to each of these words and sentences. Each subject was directed to give a verbal response to each word or sentence as promptly as possible and simultaneously to press down firmly with his fingers upon two rubber disks. The fingers were resting on these disks at all times, and therefore it was possible to study the hand responses just preliminary to the main responses These preliminary responses were the significant ones studied. They appeared to record either amounts of tension prior to the main responses or else the beginnings of responses which the subject endeavored to inhibit. Measurements were made of the heights of these preliminary runs on the kymograph records, and statistical analyses were made of them

2. A statistically reliable difference was obtained between the preliminary responses to the experimental (or controversial) words and the preliminary responses to the control words The strongest responses were made in connection with social relations where such issues as divorce, companionate marriage, and prohibition were raised. The second strongest responses were elicited by religious issues Then followed racial questions and, lastly, economic-political questions. It is believed that the reliability of the method will be dependent to an important degree upon the strength of the stimuli used. It seems probable that it would find special application in the study of delinquents and psychopaths, for whom certain critical concepts would be especially potent

3 Emotionally toned attitudes as here measured are not highly correlated with general emotionality as determined by the Pressey X-O Test, the correlation between the two being only .29

4 Only small agreement was found between the test results and the judgments of fellow students in ranking the subjects from highest to lowest as to the strength of their emotionally toned attitudes. The agreement was greatest in the field of social relations, but even here the correlation was only 25. It is believed that while this low correlation is due in part to the errors of measurement in the test, it is also due in part to the unreliability of the ratings.

5 In spite of the lack of agreement between the test results and the only other available criterion (the judgments of fellow students) in ranking the subjects from highest to lowest, the test was rather successful in determining the relative strengths of the four types of issues in "stirring up" the individual The average coefficient of

mean square contingency between test ranks of the four types of issues and students' self-ranks of the four issues was 48 (the maximum value of C for a 4 x 4 table being .86) This value was almost identical with the average coefficient obtained between self-rankings and fellow-student rankings of the issues The average coefficient between test rankings and fellow-student rankings of the issues was 42.

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UNE MESURE OBJECTIVE DES ATTITUDES DE TONUS ÉMOTIF

(Résumé)

On a formulé une série de mots et de phrases ayant rapport à des questions controversables aux champs de la religion, de la race, des relations sociales, et de l'économie et de la politique afin de stimuler des réponses qui montreraient des attitudes de tonus émotif. Ces stimuli expérimentaux avec une série de mots non controversables ont été présentés individuellement à 61 étudiants universitaires. On a demandé à chaque sujet de donner une réponse verbale d'un mot à chaque mot ou phase aussi vite que possible et en même temps d'appuyer les mains sur deux disques en caoutchouc La méthode employée a ete une adaptation et un développement de l'*Ausdrucksmethode* employée par Luria dans son investigation des criminels en Russie. Elle a consiste à enregistrer les réponses des mains sur un tambour kymographique. Les reponses faites directement avant les grandes réponses ont été les signifiantes On a mesure et traité statistiquement celles-là On a trouvé que les attitudes les plus fortes existent dans le domaine des relations sociales, les plus faibles dans le domaine de l'économie et de la politique. Le test, bien que termine en 9 minutes, a donné des résultats ayant le même accord avec les estimations de soi des sujets qu'avec les estimations par des amis de plusieurs annees OLSON ET JONES

EIN OBJEKTIVER MASSSTAB FÜR GEFÜHLSBETONTE STELLUNGSNAHMEN

(Referat)

Es wurde eine Reihe von Wortern und Satzen, welche sich auf strittige Fragen in den Gebieten der Religion, der Rasse, der sozialen Verhaltnisse, und der Ekonomie-Politik bezogen, arrangiert, in der Absicht, gefuhlsbetonte Stellungsnahmen ("emotionally toned attitudes") offenbarende Reaktionen hervorzurufen Diese experimentellen Reize wurden nebst einer Serie bestehend aus nicht-strittigen Wortern 61 Studenten individuell angeboten Jede Vp wurde ersucht, so schnell wie moglich mit einer Erwiderung bestehend aus einem einzelnen Wort auf jedes Reizwort und jeden Satz laut zu reagieren, und zu gleicher Zeit mit beiden Handen auf zwei runde Gummiplatten herabzudrucken Die angewandte Methode war eine Anpassung und Erweiterung der von Luria in seinen Untersuchungen an Russichen Verbrechern gebrauchte Ausdrucksmethode Sie bestand aus der Registrierung der Handreaktionen mittels eines Kymographs Die unmittelbar vor der Hauptreaktion erscheinenden Reaktionen erwiesen sich als die bezeichnenden. Letztere wurden gemessen und statistisch behandelt Die am starksten gefuhlsbetonten Reaktionen zeigten sich im Gebiete der Ekonomie und Politik Der Test, obwohl er innerhalb 9 Minuten erledigt werden konnte, lieferte Resultate welche mit Selbstschatzungen der Vpp ebenso genau ubereinstimmten wie Schatzungen von Freunden, mit denen die Freundschaft schon mehrere Jahre bestand OLSON UND JONES

THE DOUBLE ALTERNATION PROBLEM II. THE BEHAVIOR OF CHILDREN AND HUMAN ADULTS IN A DOUBLE ALTERNATION TEMPORAL MAZE*[1]

From the Psychological Laboratories of Clark University

LOUIS W. GELLERMANN

INTRODUCTION

In the first experiment of this series (2) I found that the monkey, in relation to raccoons and rats, shows the same relative ability in the double alternation problem that he does in the delayed reaction experiment Thus far, all subjects tested in the double alternation temporal maze fit into a genetic series similar to that found for the delayed reaction. Human subjects show greater capacity in the latter problem than do infra-human subjects. The work of the present experiment was undertaken to determine whether human subjects have this same relative ability in the double alternation temporal maze. In particular this experiment seeks to answer the following questions

1 Can children and human adults learn the double alternation problem in the temporal maze.

2 Can human subjects extend the double alternation of responses to a series of greater length than that upon which they were trained?

3 Does anything in the behavior of the human subjects during and following the solution of the double alternation problem indicate the nature of the processes which they utilize to supplement non-differential interoceptive and exteroceptive stimuli encountered within the temporal maze?

In order to make the results with human subjects more nearly comparable with those obtained with monkeys and other infra-human subjects, I decided to conduct this experiment as nearly like the one

*Accepted for publication by Walter S Hunter of the Editorial Board and received in the editorial office January 19, 1931.

[1]The writer takes pleasure in expressing his indebtedness to Dr. Walter S. Hunter of Clark University, under whose direction these experiments were conducted The actual experimental work described in the present paper was conducted from July, 1929, to April, 1930

with monkeys as I could The human subjects were given no verbal instructions during the experiment except in a few cases, to be indicated later, where the subjects refused to keep moving through the maze Even this would have been unnecessary had it been possible to secure increased movement with the human subjects by means of hunger or punishment as had been done with the monkeys

Apparatus

The temporal maze used with human subjects was similar to that used with the raccoons and monkeys. In all essential aspects the two were identical Figure 1 shows the ground plan of the maze which was located in a quiet inside room of the laboratory The walls and doors of the maze were constructed of wall-board supported upon a wooden framework The apparatus was 6′ in height, and its outside dimensions were about 19′ wide by 12′ deep. All alleys were 3′ wide The doors were hung on the outside wall of the apparatus with high-grade door hinges All doors were controlled from a central point at the front of the maze by means of a tightly hinged lever and rod system. In actual operation the doors could be

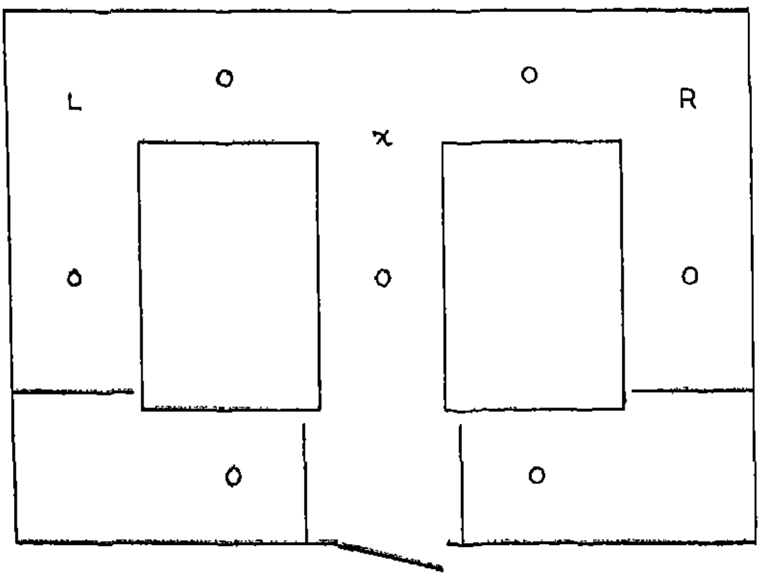

FIGURE 1
Ground Plan of Temporal Maze for Human Subjects

opened and closed easily and noiselessly Mounted vertically along the top front edge of the apparatus was a wall-board screen which contained three screen-covered windows giving one-way vision Entrance to the maze was gained through a door which was locked once the subject entered the maze. A single electric light in the ceiling provided illumination for the experimental room The maze was illuminated by seven shaded electric lights supported over the center of the alleys at a height of 7 feet above the floor and located at the points indicated by circles in Figure 1

The walls of the center alley were 1 foot higher than the other walls From the center alley not even the tallest subject could see the side doors or the mechanism for their control. While a subject was in the maze the room light was turned off, and the maze lights were turned on Under these conditions it was easy for the experimenter to see into the maze, but it was impossible for the subjects to see out through the screened windows Tests were conducted with about 20 persons who were requested to attempt to secure cues on the operation of the maze from any position in the center alley. Not one was able to see the experimenter in the position he occupied during experimental work or to detect when the side doors were being operated, which door was moving when told that one or both were, or whether the side doors were opened or closed. This is convincing evidence that no external cues were given by the operation of the apparatus.

METHOD

1. *Subjects.* Before regular experimental work was undertaken a group of 10 subjects whose ages ranged from 7 to 20 years were tried out in the apparatus. This preliminary work made possible an approximation of the number of trials human subjects would require to solve the problem and gave the experimenter practice in operating the apparatus and in keeping records An earlier group of about 20 subjects had been used to search for possible cues (as described above). The main experiment utilized 63 subjects who were divided into two groups. The adult experimental group consisted of 25 college students enrolled in the introductory course in psychology The children's group consisted of 38 subjects whose ages ranged from 3 to 13 years The number of subjects in these main experimental groups at each age level is shown in Table 2.

All subjects were ignorant of the nature of the experiment The

adult subjects were told that approximately an hour of their time would be required, and that nothing disagreeable would be encountered. (During a previous year some of the students had served as subjects in an experiment involving unexpected electric shock.) The fact was emphasized that an important feature of the experiment was that its nature be unknown to the subject. *At no time* was any reference made to anything which might indicate that the experiment involved a maze, walking, learning, "getting out of," or problem solution.

The children were secured at random from the district surrounding Clark University. In general, the experimenter would encounter two or three youngsters on the street and ask them if they would care to come up to the University to see some monkeys. Occasionally the children were told that they would also be requested to serve as subjects in an experiment while at the University. At least half of them, however, were told nothing about an experiment, but were simply led into the experimental room and put to work.

2. *Differences in Procedure Used with Monkeys and Human Subjects.* An important feature of the procedure used in this experiment was the minimizing of verbal instructions. Hitherto, fairly complete verbal instructions have been used in almost all maze studies, "choice" problems, delayed reaction experiments, etc., with human subjects where the results obtained have been compared with those obtained for infra-human subjects. Husband (7), in a recent paper entitled, "A Comparison of Human Adults and White Rats in Maze Learning," states that a major point of *similarity* in the techniques he used with human subjects and rats was that "preliminary orientation is brought about in the human subjects by verbal instruction and in the rats by a short period of training on a problem box." The use of this kind of verbal instruction with human subjects seems to me to introduce a major *difference* in technique. At a later point in the paper, Husband states a somewhat different position concerning the use of verbal instructions. In this case the fact that "humans start with fairly complete directions" is listed among certain "necessary exceptions" in the experimental procedure he used with his two groups of subjects. It may be that with the finger maze it is not only convenient but necessary to use verbal instructions with human subjects. This practice in the case of regular maze problems is unnecessary, and should be discontinued. As will be pointed out in the discussion of results, the use of the instruction stimulus makes it

possible for the human subject to start his work at a later stage in the learning process than that at which infra-human subjects commence work.

In the present experiments the differences in technique employed with the human subjects and the monkeys were:

1. Movement through the maze was secured with the monkeys by means of hunger and punishment, and with human subjects (when necessary) by verbal instructions.

2. The human subjects learned in one period of consecutive trials, while the monkeys ran only one trial a day until the criterion of learning was satisfied.

These differences are interrelated in that they both center in the problem of motivation.[2]

The use of verbal instructions proved necessary with only those subjects who would enter the maze but would fail to move through it. In the case of an animal exhibiting such behavior it was possible to secure locomotion by means of hunger or punishment. Since neither of these methods was practical here the following procedure was used. If a subject stood at a given point for three minutes, he was given the verbal instruction, "Keep moving." This proved necessary in the case of 12 adults and 9 children. In only one case was it necessary to use this method more than twice.

The second difference could have been avoided either by running the human subjects only once a day, or by running all trials for the monkeys on a single day. Several members of the preliminary group of human subjects were tried on the one-trial-per-day basis, but it became evident that irregularities in attendance were almost inevitable. Furthermore, the danger of communication between the human subjects (see p. 203) would have been greatly increased had the human subjects been run only once a day. For these reasons the human subjects were run during a single period of successive trials. The monkeys were run only once a day because of the difficulty of maintaining strong and relatively constant hunger during concentrated trials. It would have been almost impossible to run all of their trials on one day because of the large number of trials required by the monkeys to master the problem.

A similar problem in procedure existed in the giving of reward. With the monkeys a bit of food had been given a subject each time

[2]By motivation I mean simply getting the subject to work, i.e., to keep walking while in the maze.

he came to the front of the temporal maze, in order to keep him moving through the maze This was also a problem of motivation. Had the reward been given only following correct responses, it would have been necessary to use reward with human subjects in order to duplicate with them the conditions of the experiment with monkeys However, this was not the case, and in consequence reward was not used with human subjects This introduced an apparent but (I believe) unreal difference in technique In practice the instruction stimulus, "Keep moving," after three-minute pauses proved to be adequate to secure regular movement throughout the maze[8]

3. *Procedure Used with Human Subjects* After securing the subject's name, age, and school grade, he was admitted to the maze in the following manner. I opened the entrance door to the maze and turned the maze lights on and the room light out. Then I turned to the subject and said, "Would you like to go in there and look around?" All doors of the maze were open at this time. While the subject was in the maze, I took the position which I occupied during experimentation, and waited without saying anything until the subject came out of the maze. As he left the maze, I closed the entrance door behind him At the beginning of each trial I opened the entrance door and said, "All right," and at the conclusion of each trial I opened the entrance door again and said, "Out." *"Would you like to go in there and look around?" "All right," "Out,"* and the instructions *"Keep moving"* (discussed above) *were the only things I said* during the entire experiment with each subject. This rule was followed even where the subject made comments or asked questions.

Three preliminary trials were given each subject. In these he could go either R or L on the first response, but must go the other way on the second response. Each regular trial for the adults consisted of eight responses in the order $R\ R\ L\ L\ R\ R\ L\ L$. For the children each trial consisted of four responses $R\ R\ L\ L$ An interval of about 15 seconds elapsed between trials During this time the subject usually sat on a chair placed near the entrance door. The procedure of operating the maze during these trials was exactly like that used for the monkeys. Complete records were kept of responses, extra moves through the maze, time of each response, everything the

[8]Both reward and additional instruction stimuli proved necessary in the work with three- and four-year-old subjects (see p. 209)

subject said, and any other significant features of the subject's behavior.

The criterion of learning was three perfect trials in succession. In the trials following learning both side doors were open, and with a few subjects all doors were open at this time No additional controls were used with human subjects

Following the attainment of the criterion of learning, and without warning to the subject, the series of responses was extended to twice its usual length If the subject ran this correctly, it indicated that he could extend the alternation of response beyond the length of the series used in the training period. In some cases several extended series were used one after another until the subjects had performed one correctly

At the conclusion of each experiment the subject was asked two questions The first was, "What did you think of it [the problem]?" While the subject expressed himself I listened in a manner calculated to encourage the subject to talk, until he had stated the general solution of the problem (and this was done by every subject), i.e, the general proposition of two to the right, two to the left I then asked him, "How did you learn that [the solution]?" What the subject said in response to these questions was recorded verbatim

The double alternation problem is such that its solution could be easily communicated from one subject to another A consistent effort was made to prevent this The adult subjects had been urged to maintain secrecy concerning the experiment until after the last subject had taken part in it They had been told that secrecy concerning the nature of the experiment was one of its features The children were secured in such a way as to make communication between them very improbable. Any one child knew only two or three others who served in the experiment, and all of these were tested on the same day. The members of these small groups were tested one after another and did not see each other until all were through. The following means was taken as an additional precaution against communication between subjects. After each subject had answered the questions stated above, he was reminded of the fact that during the experiment he had received no verbal instructions It was pointed out to him that if any subject undertook the experiment with even the slightest instructions, the results secured would be worthless. I believe that all of the subjects saw the point and cooperated. Additional evidence in this direction is the fact that with both children

and adults the correlation between trials and the order of participation in the experiment was .01 and .07 respectively. (See also Figure 2 and the discussion on p. 212.)

Results

1. *Learning*

a. Behavior typical of successive stages in learning. The human subjects exhibited the same general stages of learning the double alternation temporal maze as did the monkeys. These were: (1) a "random" stage marked by many extraneous moves through the maze, (2) a stage of regular running, and (3) a stage of hesitation prior to certain of the responses. In the first stage various of the human subjects duplicated essentially all of the "random" responses described for the monkeys (2, p. 58). One subject (16 years old) never proceeded beyond this stage. She showed evidence of fright the first time the right-side door was closed behind her as she came to the front of the apparatus. Following this she went up the center alley and to the left, but stopped at the left door and attempted to swing it shut. Then she started to go past it very slowly, but the moment the door began to close she hurried back to point *x*. This behavior was repeated a great many times on both sides of the apparatus (the right-side door had been reopened). Because of failure to go to the front a second time she was unable to finish her first preliminary trial. With the use of additional verbal instruction this condition might have been obviated. Since, however, only one subject exhibited such behavior, no variation in the general procedure seemed advisable. Instead, this subject was not used further, and she is not included in the total of 63 subjects mentioned above. It seems likely that her disturbance was emotional in character. Another subject exhibited somewhat the same behavior during the first stage, but finally completed the problem without verbal instructions. This subject was a 20-year-old college student with the third best intelligence rating of the adult group. The behavior to be described appeared on his first regular trial. He walked back and forth in the back section of the maze many times in succession before coming to *F*. Altogether he made 167 such trips during his first regular trial. At the end of this trial he said, "If I'd tried that sooner would I have gotten out?"[4] (The experimenter never responded at all to questions.) Although his performance upset the time records for the

[4]All verbal responses cited in this paper are given verbatim.

group (he took 2588 seconds on one trial), he learned the problem on his second trial His performance on the first trial was similar to that of the monkey, Sis, who took 6 hours to complete her first response.

Extra moves through the maze were discontinued by the human subjects in much the same way as had been done by the monkeys This was accompanied by such verbal responses as· "You aren't supposed to go to the doors if they are closed, are you?" and "I'm almost beginning to see what this is all about" Some of the subjects said nothing, but simply stopped going all the way to the closed side doors

After extra moves through the maze had been eliminated, the subjects were in the second stage of learning. During this stage the subjects responded typically in the series *L L L R* or *R L L R,* trial after trial (This is simple alternation behavior, see p 217) They gave no evidence at the time of response of hesitation behavior, but turned promptly to one side of the maze or the other

The third stage of learning was accompanied in human subjects by hesitation at the point x, and by such verbal responses as· "I've just been walking around. I don't know which way I have been going, but I'll bet the idea is to find the way where all doors are open", "Are you supposed to walk around this thing until all the doors are open? Oh, I don't suppose you'll tell me", and "I've been trying to work out a plan, but you've got me baffled" Some of the subjects snapped their fingers following incorrect responses, while others went so far as to swear about them This behavior appeared very late in the learning series

In the case of the human subjects who learned the problem in the least number of trials, one or more of these stages appeared only briefly. With some subjects the first stage was even confined to the first preliminary trial One factor which doubtlessly led quickly from the first to the third stage of learning was the self-administration of instructions in the general form, "This is a problem to solve." This behavior probably occurred to some degree in all but the youngest subjects.[5] For this reason it was particularly important that no verbal instructions were given by the experimenter Had the human subjects been told that the maze was a problem to solve, or that they

[5]Instruction stimuli may be given to the subject by himself as well as by an experimenter In the former case the instruction stimuli are habitual responses, and in the latter they arouse habitual responses of a "problem solving" type (3, p 335-336)

should find their way out as quickly as possible, the solution of the problem would probably have been limited to very few trials in the case of most of the subjects The case of a nine-year-old girl in the preliminary group of ten subjects will serve to illustrate this point. Following her third preliminary trial she said, "You know, Mr. Gellermann, I really should tell you this problem is too easy for me" It took her only one trial to learn the problem and in this trial all her responses were to the right When she had finished the experiment, she said, "That's very easy. All I have to do is to try it once, and think about it" She had apparently administered her own instruction stimulus Such behavior should not be encouraged in human subjects by means of verbal instructions in experiments the results of which are to be compared with results for infra-human subjects This general point may not apply as directly to the ordinary spatial maze problem as it does to the double alternation temporal maze problem, since in the former the solution may not depend upon a verbal formulation in the same way that it evidently does in the temporal maze

b Examples of verbal behavior during learning The following are a few complete individual records which show the coordination of various types of responses and verbal behavior. In these records it is possible also to detect evidence of the stages in learning described above. Most of the subjects showed a tendency to talk, but, when I did not answer them, a great many became silent No instruction was given concerning talking during the experiment

An adult subject who solved the problem on his first trial. On his first preliminary trials he said, "Quite interesting", after the third preliminary trial, "I'm almost beginning to see what this is all about" On his first response before coming to the front of the right side, he made an extra trip over to the left, and while returning to the right, said, "There is only one way to get out." Preceding his third response he hesitated, and said as he went left, "No, let's try this—yes, it's open." On his fourth response to the right he said, "There is no use trying that door," and went to the other side Following his seventh response he said, "This is beginning to be easy" After the eighth, "Yes, it is easy" Both of these responses had been correct On his next trial all responses were correct After the first 2 (*R R*) he said, "This is easy," and following the third (*L*) he said, "I guess I'll find all the doors open now."

An eleven-year-old who took 25 trials during learning On

his first preliminary trial he said, "Am I supposed to keep moving around? Do I start from here?" He made many extraneous moves during his first 12 trials In trial 13 he said, "Am I supposed to push on the doors, or am I doing all right?" (end of first stage) In his fourteenth trial he said, "Do I have to keep on going until I find the right way?" On his sixteenth trial, "It is just the way you go around that you have to find out I haven't any idea which way that is" (beginning of third stage) It took him 9 more trials to learn the problem On his first correct performance, he said, "I knew it was just the way you walk through the doors."

At the close of the experiment each subject related that he had formulated his solution verbally in the general form, "twice to the right, twice to the left, etc." The following examples will illustrate typical ways in which this appeared with children and human adults:

Ten-year-old requiring 14 trials to learn "First I thought all the walls would close in, and you were going to test my nerve or something like that Then I found the doors were open, and I kept on walking I thought there was something to it, because sometimes the doors were closed After awhile I found you must go around each place twice"

Twelve-year-old requiring 22 trials to learn: *During learning,* "What's this?" "Can you watch me through that?" "Boy! I was scared when that first door closed behind me I tried to go back through that door, but it didn't work" "Is this what I am supposed to do? Am I supposed to walk around in here?" *After learning,* "It's a lot of walking. First I didn't know what to do I thought the doors opened by electricity in a certain way—twice around to the right of it, and twice around to the left of it. Then the last time you made me do it double." In response to the question, "How did you learn it?" he said, "When I finally decided to get the knack of it I took four or five trials, and told by which doors were closed which way I should go"

Adult requiring 2 trials "I thought I would find one of those doors closed, the last couple of times, I expected a change. I hit one of the doors the first trial, but the second trial I tried the right until I found it closed on the third time Then I went the other way, so I figured if I went twice each way I'd always find the door open"

Adult, 4 trials to learn. "I think I got on to the idea pretty early, and most of my errors were made experimentally I tested it out, and then went the way the doors were open First

I learned to go to the right, and tested it, then I went twice each way"

Adult, 5 trials "It is like a safe, you have to find the proper combination Twice to the right, and twice to the left, endlessly until you let me out" In response to the question, "How did you learn it?" he said, "After I saw the first closed door, I realized there was a problem I tried right once, and the left once, but it didn't work Then I tried the right twice, and the left once, but it didn't work. Then I tried to go back, to the door that had just been closed, but that didn't work either. Then I just happened to find out that twice to each side worked, so I kept it up—and it worked"

Adult, 9 trials "At first I was absolutely lost, but soon I discovered there was a system. It was twice to the right, and twice to the left Finally, I didn't even look, I walked automatically."

Adult, 10 trials "I started on one side, but every other time on each side I'd get stopped, so I went twice on each side, and it was all right" (This subject responded typically *R L L R R L L R,* or in simple alternation as will be discussed later He did make an error *every other time* on each side)

Adult, 12 trials "It seemed to dawn on me at the end of five or six times that the idea was to go through the open doors. I found that I must go through one set of doors twice, then alternate, and go through the other set twice"

Adult, 16 trials This subject performed four of his sixteen learning trials correctly. In one case, two of these were in succession, but on the following trial he made errors of a peculiar sort on responses 1 and 5 Keeping one foot in the center alley, he leaned far out toward the left side alley, apparently to see if the left door were closed. Following this trial, he remarked to me, "I was just trying something of my own." Following learning he said, "I found I always had to go to the right, but I could never go on one side more than twice Near the last I thought I had the system, but I was not sure so I looked to find out" (Why he kept one foot in the center alley is uncertain.)

c Quantitative data on learning Table 1 presents the general facts concerning the number of trials required to learn the problem for the adults and children At first glance it appears that the adults require many less trials than did the children The difference between the averages of these two groups divided by the sigma of the difference is 6.18 From one standpoint the 8-response

problem of the adults was more difficult than the 4-response problem of the children, and the significance of the difference in the average number of trials required to learn for these two groups is thereby enhanced. From another standpoint, however, it appears that a single adult trial is approximately equivalent to two trials for the children in that two double alternation series of four responses are included. From this standpoint the adults required an average of 12.48 trials to learn a problem equivalent to that of the children. Even in this case the adults required less trials to learn than did the children. The reliability of the remaining difference indicates that the chances are about 93 in 100 that a true difference above 0 was obtained.

Table 2 presents the average number and the range of trials required for learning at each age level of both main experimental groups. Although in the children's group averages decrease with age (with one exception), it is improbable that true differences are represented. The ranges show marked overlapping between all of the age groups. It is true, however, that both the minimum and maximum number of trials for the younger children exceed those for the older children. The correlation (rank-difference) of age and trials required to learn for the 36 children is .27, and that for the adults is .02. This low positive correlation for the children indicates that the average number of trials to learn the double alternation temporal maze does tend to decrease with age in the fashion shown in Table 2. The correlation (rank-difference) between age and trials required to learn for the 63 subjects of both groups is .35±.08. In obtaining this coefficient the number of trials for each adult subject was doubled, since each adult subject made eight responses per trial instead of four.

It may be noted in Table 2 that the two youngest subjects did not learn the problem. In both cases the children became tired of working in the maze. Additional verbal instructions were given to keep them walking. They were complimented upon their performance, urged to keep moving, and pennies were given as reward. Even with these measures it was possible to complete only 30 and 42 trials with the three-year-old and four-year-old subjects, respectively. The three-year-old subject was in the second stage of learning when work with her was discontinued. Her record shows that slightly less than half of her responses were correct. No improvement is noted near the end of the 30 trials, nor did she adopt any regular

TABLE 1
DATA ON TRIALS DURING LEARNING FOR CHILDREN AND HUMAN ADULTS

	Adults	Children
Number of subjects	25	36†
Average age in years	20 6 (1 3)*	9.4 (2 2)
Range of trials required for learning	1–16	4–37
Average trials required for learning	6 2 (3 8)	15 4 (7 6)

*The figures in parentheses are sigma
†The records of the three- and four-year-old subjects are not included in this table.

TABLE 2
AVERAGE NUMBER AND RANGE OF TRIALS REQUIRED FOR LEARNING AT EACH AGE LEVEL
(For ages 3 to 13, 1 trial is 4 responses)
(For ages 18 to 23, 1 trial is 8 responses)

Age	Number of subjects	Average trials to learn	Range of trials to learn
3	1	(did not learn in 30 trials)	
4	1	(did not learn in 42 trials)	
5	2	22 5	8 – 37
6	3	18.3	8 – 29
7	4	17 2	10 – 26
8	2	16 0	11 – 21
9	3	15 3	5 – 25
10	8	15.6	4 – 23
11	9	13.9	4 – 25
12	3	13 3	7 – 22
13	2	9 0	5 – 13
18	3	4 2	2 – 7
19	6	6.3	2 – 10
20	6	7 8	2 – 16
21	6	7 3	1 – 12
22	3	3 6	2 – 6
23	1	3 0	3

series of responses, but she was making no extra moves in the maze. The four-year-old subject made just half of all his responses correctly, but he exhibited a slight improvement near the end of his 42 trials By that time he was in the second stage of learning, and was responding *R L L R*. No signs of hesitation preceding responses had appeared

TABLE 3

DATA ON ERRORS DURING LEARNING

	Adults	Children
Average errors per subject	16 36	30 19
Average errors per trial	2 62	1 96
Adult 1 trial—8 responses Children' 1 trial—4 responses Percentage of responses wrong	32 80	49 00

TABLE 4

TIME RECORDS DURING LEARNING

	Adults	Children
Average time first trial	288 4	80 4
Average time last trial	88 0	35 4
Average total time	871 5	708 2
Range of time	170–2678	199–1371
Average time per trial	139 7	46.0
Rate of walking in feet per second	3 9	4 5

TABLE 5

CORRELATIONS

	Adults				Children	
	ρ	P.E.			ρ	P.E
Trials vs age	02	14			28	11
Trials vs order of taking the experiment	07	14			01	12
Trials vs. psychology marks	21	13				
Intelligence vs trials	58	09				
Intelligence vs errors	52	10				
Intelligence vs time	36	12				
Trials vs age, for entire group			35	08		

Table 3 presents general data concerning errors made in learning by both groups of human subjects There appears to be a genuine difference here in that the average adult made only 32.8% of all his responses incorrectly, and the average child committed errors in 49% of his responses. This may be related in some way to the fact that the children consumed a relatively large number of trials in the first and second stages of learning, during which at least half of their responses were usually incorrect Only during the third

stage of learning do error records fall below the 50% mark. The adults arrived at this stage of learning much more quickly than did the children

Data concerning the time records (in seconds) of human subjects during learning are presented in Table 4 As in the usual learning situation, more time was consumed during the early trials than later This is shown by the difference in the average time of all first trials and all last trials In comparing the time records for these two groups, it must be borne in mind that the children made only four trips around the side of the maze (122 5 feet) and the adults made eight such trips (250 5 feet) per trial The children moved more rapidly through the maze than did the adults, taking into consideration the distance they had to travel The fact that the average total time for the children is almost as great as that for adults is consistent with the fact that the children required over twice as many trials, on the average, as adults A wider range in learning times was found for adults than for children. It is possible that this is in some way related to the fact that the adults did not adapt as quickly to moving through the maze as did the children It was necessary to use the "keep moving" instruction with 48% of the adult subjects, but with only 25% of the children The fact that the most rapid learning appeared in the case of certain adult subjects is made evident by the minimum time of 170 seconds required by one adult subject to learn the 8-response problem. This time was all consumed on a single trial.

Table 5 records coefficients of correlation (rank-difference) between trials and age, order, and semester marks in elementary psychology, and between intelligence (Thurstone Psychological Examination for College Freshmen) and trials, errors, and time I have already commented upon the correlation between trials and age The correlations between trials and order of taking the experiment indicate that those who worked last in the experiment made no better records than might be expected due to chance This is evidence of the improbability of communication between subjects throughout the course of the experiment Figure 2, in which individual trial records for adult subjects are plotted in the order in which these subjects took the experiment, shows that the zero coefficient of correlation represents the true situation that obtained between trials to learn and order of taking the experiment. It may be noted that the average number of trials required to learn for the

first five adult subjects to participate in the experiment is lower than the same figure for the last five adult subjects The correlations between intelligence and trials and errors are about the same size as those usually found between intelligence and school marks The low correlation between intelligence and time records is to be expected in view of the fact that a large variation in the speed of walking through the maze existed among the members of the group. A second factor contributing to this low correlation was the performance of one subject high in intelligence who took an extraordinary amount of time on his first trial (see p 204).

Table 6 includes coefficients of correlation between various aspects of the learning data. The data indicate that the temporal maze has a comparatively high reliability when evaluated by these methods. The coefficients are consistently higher in the children's group, in which 36 cases were included The low correlation between the errors on odd and even responses is due to the peculiar situation which exists in the double alternation problem Fewer errors have been made on the odd-numbered responses than on the even-numbered responses by all subjects tested in these experiments. Details concerning this situation will be presented later (see p 215) That this

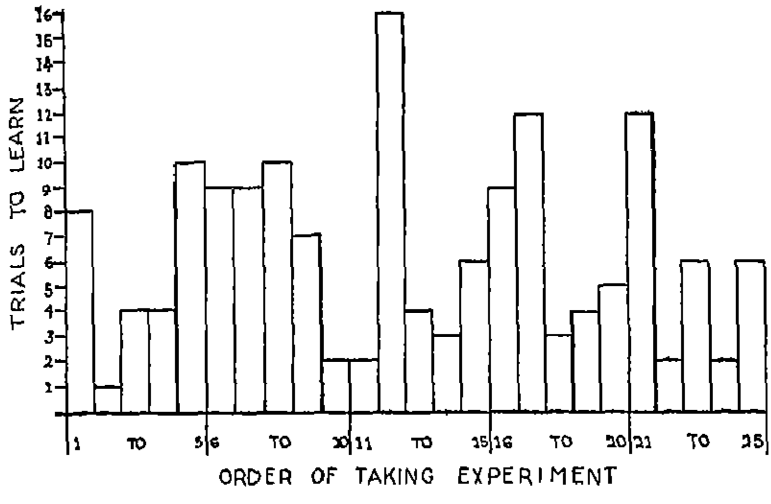

FIGURE 2

INDIVIDUAL TRIAL RECORDS FOR ADULT SUBJECTS IN THE ORDER IN WHICH THESE SUBJECTS TOOK PART IN THE EXPERIMENT

TABLE 8

PERCENTAGE OF TRIALS DURING LEARNING IN WHICH THE SIXTEEN DIFFERENT POSSIBLE SERIES OF RESPONSES OCCURRED

Series	Children	Adults*	Monkeys
R R R R	7	6	1.3
R R R L	1.1	3.5	5
R R L R	1.3	5.8	1.0
R R L L	6.1	28.2	2.3
R L R R	.5	2.9	1.0
R L R L	.9	1.9	2.8
R L L R	27.1	19.6	22.3
R L L L	18.2	12.5	55.7
L R R R		.3	3
L R R L		1.3	
L R L R	2.5	1.6	
L R L L	3.8	6.7	3
L L R R	1.8	2.2	.5
L L R L	9	1.9	5
L L L R	28.5	6.1	3.5
L L L L	5.9	4.8	8.1

*These data are based on the first four responses for adults

TABLE 6

CORRELATIONS BETWEEN VARIOUS ASPECTS OF LEARNING DATA
(Coefficients of reliability)

	Adults		Children	
	r	$P E_r$	r	$P.E_r$
Trials vs. errors	88	03	93	02
Errors on odd vs even trials	83	04	.98	01
Errors on first vs. last half of trials	75	06	92	.02
Errors on first vs last half of maze				
Responses 1-2-3-4 vs 5-6-7-8	.86	04		
Errors on odd vs even responses				
Responses 1-3-5-7 vs. 2-4-6-8	.44	11		
Errors on responses 1-3-6-8 vs. 2-4-5-7	81	05		

TABLE 7

PERCENTAGE OF TRIALS DURING LEARNING IN WHICH ERRORS OCCURRED ON EACH OF THE RESPONSES FOR DIFFERENT SUBJECTS

	Response			
Subjects	1	2	3	4
Two youngest children	45 8	66.7	40 3	51.4
Children 5 to 13 years old	41.2	85 9	5 6	63 0
Adults first 4 responses	30.8	55 1	16.7	41 7
All human subjects	36 2	73 2	11.3	54 4
Monkeys	13.7	94.4	6 8	29 9

TABLE 9

RESULTS OF TESTS WITH EXTENDED SERIES OF RESPONSES

Subjects	Number of subjects in group	Number of subjects perfect on first extended trial	Results with other subjects in the group
Adults	25	23	both perfect on second extended trial
Children 7 to 13 years old	31	29	both perfect on second extended trial
6-year-olds	3	1	both perfect on third extended trial
5-year-olds	2	0	never perfect in 10 and 12 extended trials respectively

situation caused the low correlation between errors on odd and even responses is definitely indicated by the fact that a high correlation was obtained when two odd- and two even-numbered responses were grouped together. Such was the case in the correlation between the errors on responses 1-2-3-4 vs. 5-6-7-8, and 1-3-6-8 vs. 2-4-5-7 The reliabilities here demonstrated for the double alternation temporal maze compare favorably with those reported by Stone and Nyswander (8), and Tolman and Nyswander (9). From one point of view, the temporal maze is a type of multiple-T maze similar to those used by Stone.

d. Relative difficulty of responses Let us now consider the difficulty encountered by the human subjects in learning each of the responses in a trial A comparison of results of this kind for human subjects with similar results for infra-human subjects may throw some light upon the nature of the double alternation problem. Table 7 shows the percentage of errors made by different subjects on each of the four responses The data for adults are not directly comparable with those for children, since the adults worked on eight responses per trial instead of four responses The data for the adults are presented for the first four responses of each trial, since they more nearly approximate the children's group than the second four.

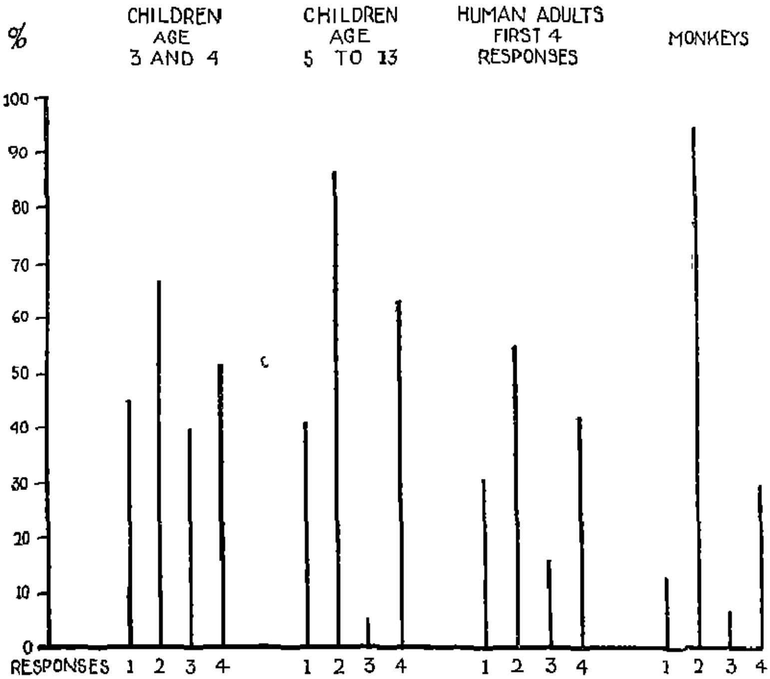

FIGURE 3
PERCENTAGE OF TRIALS DURING LEARNING IN WHICH ERRORS WERE MADE BY DIFFERENT SUBJECTS ON EACH RESPONSE

Similar data on the average performance of the monkeys are included in the table for purposes of comparison. In Figure 3 the percentage of errors made by different subjects on each response is represented graphically. Data for adults are taken from the first four responses of each trial. The relative order of difficulty of responses from hardest to easiest is 2-4-1-3 for all groups.[6] It will be noted that the percentage of errors for the two youngest children, who did not learn the problem, shows the same order of difficulty, even though all of their records approach 50% (chance).

[6]For adults, the second group of four responses shows this same order of difficulty In general, the second group is easier than the first. Over one-third of the trials with adults contain no errors among the last four responses.

The most striking thing which appears in these data is the large percentage of errors made by the children on responses 1 and 4. This indicates that with the children (and to a lesser extent with adults) the first response was not definitely fixed at as early a point in learning as with the monkeys. In order to find the explanation of the large number of errors made by the children on response 4 we must look further. The typical series of responses noted for monkeys were, in the order of their appearance, *R L L R*, *R L L L*, and *R R L L*. This order of series did not appear very definitely with the human subjects, although, with those subjects who required the greatest number of trials, the series *R L L L* did appear shortly before learning. On the other hand, the series *L L L R*, which occurred infrequently with the monkeys, was very common with the human subjects. In Table 8, which shows the percentage of trials in which the 16 different possible series of responses occurred for children, human adults, and monkeys, the facts just presented are clearly demonstrated. With children, the leading types of responses, in the order of their frequency, are *L L L R*, *R L L R*, and *R L L L*. The preponderance of the first two of these series is due to the tendency of the children toward simple alternation, together with the fact that the first response did not become fixed at an early point in their learning. In Experiment I it was pointed out that the behavior sometimes referred to as "alternation after success" may also be explained in terms of simple alternation of trips from the point *x* to the sides of the temporal maze (2, p. 62). No matter which way the children made the first response, this simple alternation of trips from *x* led to a correct response 3 and an error on response 4 in either the series *L L L R* or *R L L R*. It was this simple alternation of trips from *x* in the case of the human subjects that led to a large percentage of errors on response 4. With the children, the third response was the first to become correctly fixed. Following it, responses 1 and 4 were learned, and then response 2. The adults also tended to follow this order in learning their responses. This is a different order than that found for monkeys, with whom the first response was learned first.

e. Simple alternation vs direction tendency. These differences in the behavior of children and monkeys in the temporal maze are consistent with other facts and tend to support the contention that the solution of the double alternation problem requires a different type of ability, than that demanded for the solution of the ordinary

spatial maze. In the first place, the feature of the temporal maze most similar to the ordinary maze is found in the subject's learning to make the correct first turn in response to entry. Results obtained by Hunter and in the present series of experiments indicate that the order of ability to form this association is, from best to poorest, rats, raccoons, monkeys, and children. This order is the reverse of the order found for the ability of the same subjects to perform the double alternation problem. Secondly, the most prominent tendency toward simple alternation was found with the children. It led to a percentage of errors on the fourth response much greater than that found for monkeys (Table 7). The monkeys tend toward simple alternation, but this series (*R L L R*) occurred less than half as often with them as did the series *R L L L* (Table 8). Furthermore, the series *R L L L* was more prominent with raccoons than with monkeys and was most definite of all with rats. This series of responses appears to be the result of a *direction tendency* functioning in the temporal maze, and is much more prominent in the performance of rats than with human subjects. Husband reports a similar difference in the type of reactions (errors) made by human subjects and by rats (7, p. 375). He found that human subjects tend to alternate, and that rats tend to maintain a direction. The series *R L L L* is the result of two factors; the first turn is associated with entrance to the maze, and the others are all toward the side of final exit. Hunter found with rats and raccoons that those animals which learned the series *R R L L* would on eight responses go *R R L L L L L L* (4, 5). This tendency to respond to the left may be thought of as a direction tendency, as suggested above. The prominence of the direction tendency in the rat is further shown by the recent work of Dashiell (1). Results secured with the temporal maze indicate that the *tendency toward simple alternation* and the *direction tendency* occur in the opposite relative order with the subjects thus far tested. The former occurs in increasing degree with rats, raccoons, monkeys, and human subjects, while the direction tendency is most prominent in the first members of this list.

2. *Extension of Series.* After the subjects had satisfied the criterion of learning, the question still remained, "Can human subjects extend the double alternation of responses to a series of greater length than that upon which they were trained?" In order to answer this question each subject was tested as follows. On the trial immediately following the three correct successive trials in which he

met the criterion of learning, the series of responses was extended to twice its usual length without warning to the subject Table 9 shows the results of the trials with extended series for all subjects so tested.

In the adult group 23 subjects ran the extended series of 16 responses without error on their first trial Four of these hesitated slightly after completing 8 responses, and two hesitated after completing 12 responses Of the two subjects who failed to make the extension correctly on their first attempt, one made an error on response 9 after which he performed the series correctly. I decided to keep him going, and found that he made an error on number 17 At this time he said, "That's funny I got out on the left side before." The other subject made an error on response 10 and then completed the series correctly. After the experiment he stated that when he found the series was extended he anticipated a change in the problem Both of these subjects performed the extended series correctly on their second trials Since the conditions of the experiment demanded the extension without verbal instructions from the experimenter, the subject was required to administer his own instruction stimulus It is interesting to note that only two of the 25 subjects in the adult group proceeded under instruction stimuli at variance with the plan of the experimenter

The youngest children encountered difficulty in making the extension of double alternation from 4 to 8 responses Neither of the five-year-olds succeeded in making the extension within the number of trials given One of these subjects had learned the 4-response problem in 8 trials He failed on his first three attempts to extend the double alternation to 8 responses. I questioned him concerning his solution of the problem, and found that he had formulated it in terms of "two that way, and two that way [pointing]." He tried the extension three more times with the result that the double alternation of the first 4 responses broke down I then tried him for 8 more trials of 4 responses each, the last 3 of which were correct He was able to tell me what he intended to do, before entering the maze, but each time he tried the extended series he would make errors on responses 5 or 6 On trial 31 he responded *R R L L R* (at this point he said, "I did it right") *L L R* ("I can't get it") On coming out of the maze, he said, "I don't know—I don't know how to count." Work with him was discontinued at this point Following his satisfaction of the criterion of learning, he had been given 20 trials, 12 of which were extended series. The other five-year-old,

who took 37 trials to learn the problem, was very tired of working at the time he satisfied the criterion of learning. He was given 10 trials of 8 responses each, but failed on all of them.

The six-year-old who took 8 trials to learn made the extension correctly on his first attempt. He paused for several seconds upon completing the first four responses, and then ran 4 more correctly. This subject was a talkative youngster After the experiment, in answer to the question, "How did you learn it?" he replied, "I went, and when the doors were shut I went the other way. When I went twice that way, the doors were opened, and then I went the other way twice Because I found the doors were open, I finally went around each side twice. Once I was waiting for the front door to open. Because the door didn't open, I went around each side two more times." He said all this with scarcely any hesitation. The six-year-old who took 18 trials to learn succeeded in running the extended series correctly on his third attempt. On his first two attempts he responded *R R L L L L L L*. The third six-year-old, who took 29 trials for learning, was tested seven times on the extended series Of these he performed the third, fifth, and seventh correctly His formulation of the problem was, "I thought there was going to be two, so I done it" Thus the five-year-olds did not make the extension, and the six-year-olds succeeded only with difficulty Of the 31 children from 7 to 13 years old, 29 ran the extended series correctly on their first attempt. Two of these hesitated slightly after the fourth response. The two subjects who made errors on their first attempt at the extended series above each responded *R R L L L L L L* Each ran the extended series correctly on his second trial.

These results indicate that the double alternation problem, when mastered by the older human subjects, can be performed correctly even though the number of responses in the test series is twice that of the training series Hunter (4, 6) has found that neither rats nor raccoons are able to make this extension Rats and raccoons both make two responses to the right and all others to the left; that is, double alternation with them appears to be confined to the series upon which they have been trained The monkeys were not tested on this problem in the temporal maze, and the question of whether they can make the extension or not remains unanswered [7] The fact

[7]It will appear in the third experiment of this series that monkeys are able to extend the double alternation of responses in another type of apparatus

that human subjects encountered little or no difficulty in the extension of the double alternation of responses is closely related to the nature of the solution used by human subjects Solution of the problem of double alternation with human subjects always was accompanied by the verbal formulation in the general form "two to the right, two to the left" This supplemented the non-differential stimuli encountered while running the temporal maze, and made possible the double alternation of responses. My results indicate that, once this verbal formulation is established, it can serve to control the double alternation of responses throughout series of various lengths. In this sense the solution of the double alternation problem may be said to involve a type of behavior which is "typically human."

Summary and Conclusions

In this experiment a main experimental group of 63 human subjects, including 25 adults and 38 children, was tested on the double alternation problem in a temporal maze. The maze was large enough for human subjects, and identical in all essential aspects with the temporal maze used with monkeys. Tests with about 20 subjects proved that no external cues were given by the operation of the maze.

All subjects were ignorant of the nature of the experiment They were given no instructions, but were simply introduced into the maze. They went through the same preliminary training as had the monkeys The procedure employed with human subjects was different from that employed with the monkeys in the following respects.

1. Motivation was secured with the monkeys by means of shock and hunger, and with the human subjects (when necessary) by the instruction, "Keep moving"

2 Human subjects learned in one period of successive trials, while the monkeys ran one trial a day until the criterion was satisfied.

These differences are interrelated in that both concern the problem of motivation

The human subjects exhibited the same general stages of learning and the same types of behavior during these stages as did the monkeys. In addition, the human subjects exhibited certain verbal behavior. At the close of the experiment each subject related that he had formulated his solution verbally in the general form, "twice to the right, twice to the left," etc

The learning records in terms of trials, errors, and time show that the human subjects mastered the double alternation much more quickly than had the monkeys, raccoons, and rats. The adult group also proved superior to the children's group. The correlation between trials to learn and age for the 63 subjects of the main experimental groups was $.35 \pm .08$. A slight decrease in the average number of trials to learn appeared at each successive age level for the children's group. The two youngest subjects tested (three and four years old) did not learn the problem in 30 and 42 trials, respectively. This, however, is no reason to suppose that they could not learn the problem if given more trials.

Correlations between trials to learn and order of taking the experiment are 0 and indicate the improbability that the subjects communicated throughout the series of tests. Correlations of intelligence and trials, errors, and time are about the same as those usually found between intelligence and school marks ($.58 \pm .09$). Correlations between various aspects of the learning data such as those usually employed in studies of reliability gave coefficients of .75 to .88 for adults and .92 to .98 for children. These coefficients of reliability compare favorably with those obtained for other forms of the multiple-T maze.

The even-numbered response of each trial proved to be more difficult than the odd-numbered responses for human subjects, as they had with monkeys. The children encountered more difficulty in learning the first response correctly than had any other group of subjects. The children also showed a marked tendency toward simple alternation behavior.

The rats, raccoons, and monkeys had all shown a predominance of the series of responses, *R L L L*, during learning. This appears to be the way in which a *direction tendency* exhibits itself in the temporal maze. With the human subjects, however, the responses *L L L R* and *R L L R* were predominant. These responses are due to the late learning of the first response and to the tendency toward simple alternation.

In the tests upon the double alternation of response in series of greater length than those upon which they had been trained, the human subjects encountered little difficulty. The six-year-old children found this problem a little harder than did the older children, however, and the five-year-old children did not succeed in making the extension in the trials they were given. All subjects gave evi-

dence that this extension was at least in part controlled by their verbal formulation of the problem

From the results of this experiment the following conclusions may be stated

1. Human subjects can learn the double alternation problem, and perform it more successfully than any subjects thus far tested in the temporal maze

2 Human subjects can extend the double alternation of responses to series of greater length than those upon which they were trained.

3 Human subjects formulate their solution of the double alternation problem verbally in the general form, twice to the right, twice to the left, etc This formulation supplements non-differential interoceptive and exteroceptive stimuli encountered within the temporal maze, to call out the double alternation of responses.

The relative abilities here demonstrated for human adults and children, for monkeys (2), and for rats and raccoons (Hunter, 4) correspond to those found for them in the delayed reaction experiment [This statement needs only slight revision as a result of the work by Hunter and Nagge (6) where much better results were secured with rats than had previously been the case These results were secured by a different method than formerly used, a method non-comparable with that used for raccoons Undoubtedly, methods could be devised which would greatly improve the raccoon's performance, but, for comparisons, it is necessary to use comparable methods] We seem to be dealing with a form of behavior which is "typically human," and which is less and less in evidence as we descend the genetic scale The situation is apparently quite different from that found in ordinary habit formation of the maze type where the response concerned is in no sense typically human, and where the above-mentioned subjects would fall into a different order on the basis of efficiency displayed in mastery

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LE PROBLÈME DE L'ALTERNATION DOUBLE II LE COMPORTEMENT DES ENFANTS ET DES ADULTES HUMAINS DANS UN LABYRINTHE TEMPOREL D'ALTERNATION DOUBLE

(Résumé)

On a testé soixante-trois sujets humains, y compris 25 adultes et 38 enfants (âgés de 3 à 13 ans), en des périodes simples d'épreuves successives dans un labyrinthe temporel assez grand pour les sujets humains et identique à tous les égards essentiels au labyrinthe temporel employé antérieurement pour les singes Tous les sujets ont ignoré la nature de l'expérience On ne leur a donné aucune instruction mais on les a introduits simplement dans le labyrinthe Ils ont montré les mêmes étapes générales de l'apprentissage que celles montré par les singes Les sujets humains (à l'exception des deux enfants les plus jeunes) ont appris le problème de l'alternation double en une à 37 épreuves Les tests ont prouvé qu'ils n'ont pu recevoir de suggestions de l'opération de l'appareil. A la fin de l'expérience chaque sujet a dit qu'il avait formulé sa solution verbalement dans la forme, deux fois à la droite, deux fois à la gauche Dans les tests de l'alternation double des réponses en des séries plus longues que celles où ils avaient été entraînés, les sujets humains ont tous réussi à l'exception des enfants âgés de moins de six ans. Tous les sujets ont montré que cet accroissement a éte contrôlé du moins en partie par leur formulation verbale du problème

Les réponses paires de chaque épreuve ont prouvé d'être plus difficiles que les réponses impaires chez les sujets humains que chez les singes. Les enfants ont trouvé plus de difficulté à apprendre la première réponse que n'importe quel autre groupe des sujets Les rats, les ratons, et les singes avaient tous montré une prédominance de la série de réponses, *D G G G*, pendant l'apprentissage Il paraît que c'est la manière de laquelle une *tendance de direction* se montre dans le labyrinthe temporel Chez les sujets humains, cependant, les séries *G G G D* et *D G G D* ont été prédominantes Ces séries sont dues à (1) l'apprentissage tardif de la première réponse, et (2) une tendance marquée vers *l'alternation simple*

Les capacités relatives montrées jusqu'ici chez les sujets humains, les

singes, les ratons, et les rats dans le labyrinthe temporel d'alternation double sont en accord avec celles trouvées dans l'expérience de la réaction retardee Il semble que nous ayons affaire avec une forme de comportement "humain en type" et de moins en moins en évidence comme nous descendons dans l'échelle génétique La situation serait tout à fait différente de celle trouvée dans la formation ordinaire des habitudes dans le labyrinthe où la réponse dont il s'agit n'est pas du tout humaine en type, et ou les sujets mentionnes ci-dessus seraient placés dans un ordre différent à cause de l'efficacité de leur apprentissage

GELLERMANN

DAS PROBLEM DER DOPPELTEN ABWECHSLUNG. II DAS VERHALTEN VON KINDERN UND ERWACHSENEN MENSCHEN IN EINEM ZEITLABYRINTH ("TEMPORAL MAZE") MIT DOPPELTER ABWECHSLUNG ("DOUBLE ALTERNATION")

(Referat)

Es wurden 63 menschliche Versuchspersonen, bestehend aus 25 Erwachsenen und 38 Kindern (3 bis 13 Jahre alt) in zeitlich abgesonderten derten Gruppen von angereiten Versuchen gepruft in einem Zeitlabyrinth welches fur menschliche Versuchspersonen gross genug und in allem Wesentlichen mit dem fruher an Affen gebrauchten Zeitlabyrinth identisch war. Alle Vpp waren uber das Wesen des Experimentes vollig unkundig Es wurden ihnen keinerlei Unterweisungen gegeben, sie wurden einfach in das Labyrinth hineingefuhrt. Sie erwiesen die selben allgemeinen Stufen des Lernens welche die Affen gezeigt hatten. Die menschlichen Vpp (mit Ausnahme der zwei jungsten Kinder) bemeisterten die Aufgabe der doppelten Abwechslung in 1 bis 37 Versuchungen Nachprufungen erwiesen, dass sich aus der Wirkung des Apparats keine Weisungen ("cues") herleiten liesen Am Ende des Experimentes behauptete jede Vp, sie hatte ihre Losung verbal formuliert in der Form zwei Mal nach Rechts, zwei mal nach Links In Versuchen mit der doppelten Abwechslung der Reaktionen ("responses") in Serien welche langer waren, als die, worin sie trainiert worden waren, hatten alle Erfolg mit Ausnahme der Kinder unter 6 Jahren Alle Vpp erwiesen, dass die Verlangerung wenigstens teilweise durch ihre verbale Formulierung der Aufgabe kontrolliert wurde

Die gleich-nummerierten Reaktionen aus jedem Versuch erwiesen, sich bei Menschen als schwieriger wie die ungleich-nummerierten Reaktionen, wie sie sich auch bei Affen erwiesen hatten Die Kinder hatten bei dem Lernen der ersten Reaktion mehr Muhe wie irgend noch eine Gruppe von Versuchspersonen- oder Tieren. Ratten, Waschbaren, und Affen hatten alle bei dem Lernen das Vorherrschen der Reaktionsserie R L L L erwiesen Dies schient die Art der Offenbarung einer Richtungstendenz ("direction tendency") in dem Zeitlabyrinth zu sein Bei den menschlichen Vpp, jedoch, erhielten die Serien LLLR und RLLR die Obergewalt Ursachen dieser Serien sind: 1) das spate Erlernen der ersten Reaktion, und 2) eine starke Richtung nach einfacher Abwechslung

Die bisher erwiesenen relativen Geschicklichkeiten von menschlichen Vpp, Affen, Waschbaren, und Ratten in dem Zeitlabyrinth mit doppelter Abwechslung entsprechen denen die in dem Experiment mit verzogerter Reaktion

("delayed reaction experiment") festgestellt worden sind Wir scheinen es hier mit einer Form des Verhaltens zu tun haben welche typisch menschlich ist, und welche desto weniger in Erscheinung tritt je tiefer wir an der genetischen Entwicklungsleiter herabsteigen. Die Lage ist hier anscheinend eine ganz andere wie bei der Entwicklung der Gewohnheiten wie sie sich gewöhnlich bei Labyrinthaufgaben findet, worin die beteiligte Reaktion keineswegs typisch menschlich ist und worin die obengenannten Vpp in Bezug auf ihre Leistungsfähigkeit bei der Bemeisterung eine andere Rangsordnung annehmen würden.

GELLERMANN

COMPARATIVE INTELLIGENCE OF IDIOTS AND NORMAL INFANTS*[1]

From The Training School at Vineland New Jersey

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Previous research with the feebleminded has developed the hypothesis that this condition represents a general tendency toward infantility. The feebleminded tend to be like children and this is reflected not only in their mentality and behavior, but also, though less markedly, in their physical constitution Mental resemblances of the feebleminded to normal children led twenty years ago to a system of classification based on mental ages or genetic levels of development. Numerous psychological investigations have since confirmed the validity of this hypothesis.

Recently the Vineland laboratory has undertaken a series of investigations to re-examine some of the theories of feeblemindedness from other points of view. Speculation on this problem develops at least five plausible assumptions as to the nature of feeblemindedness as representing (*a*) a low level of biological evolution, (*b*) a low level of anthropological evolution, (*c*) a pathological variation from the normal, (*d*) the mere quantitative deviation from the normal, as well as (*e*) the tendency toward normal infantility. Two specific investigations have been undertaken with reference to these hypotheses. (*a*) a comparison of adaptive behavior of idiots with that of anthropoids, and (*b*) a comparison of the intelligence of idiots with that of normal infants.

Numerous authorities have pointed out that the study of the feebleminded contributes significantly to a better understanding of normal human development This is because the feebleminded represent simpler stages of development which are relatively permanent and permit extensive and intensive study without growth changes on the part of the subjects. Following the same line of reasoning, we may

*Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office July 22, 1930

[1]This is a report of one of a series of experimental studies in the adaptive behavior of idiots conducted at The Training School at Vineland under a financial grant from the Elmhirst Fund

assume that the study of idiocy, the lowest grade of feeblemindedness, should contribute to better understanding of feeblemindedness in general, since the idiot would represent the very simplest stage of human development as a permanent condition not materially changing with age.

The present study is a report of a comparison of the mental abilities of idiots and those of normal children according to three scales of genetic development. These results may be compared with the companion study of idiot behavior as compared with anthropoid behavior in problem-solving situations. These studies are also designed to investigate the relative merits of the genetic technique as compared with the technique of comparative psychology for these subjects.

Technique

Genetic scales for the study of feeblemindedness have been available since 1905. The first Binet-Simon scale contained six tests, graded according to difficulty for the first two years of life, and these tests were for many years employed in measuring mental abilities of idiots. Binet did not subsequently elaborate these tests, apparently considering that the intelligence of idiots was so low that refinement by measurement was either unnecessary or impracticable.

Other psychologists, notably Wallin, emphasized the necessity for more exact measurement of the lower ranges of mental ability among normal infants and with the feebleminded Subsequent developments in psychology have justified this emphasis by calling attention to the importance of slight differences early in life which increase with age. Kuhlmann (6) in 1922 published a systematic scale of tests designed to provide for more precise measurement of the infant levels of mental development, these tests being founded on the same general principles which guided Binet Subsequently, Stutsman (7) developed a series of performance tests of a somewhat different character.

Approximately coincident with the development of these scales, Gesell (3) began his elaborate investigations of very young infants and preschool children. His results, published in 1925 and 1928, give, perhaps, the most scientific evaluation of mental development in early infancy and the most satisfactory method of expressing the developmental studies of idiots in terms of growth or genetic development.

The standard classification of the feebleminded, according to degree of feeblemindedness, defines idiots as those feebleminded children whose mental development at maturity is less than the general ability of a normal child of approximately three years of age. Within this level of ability there are, of course, many varieties of idiocy according to the specific etiology accompanying each case. Nevertheless, idiocy as a general condition may, for present purposes, be thought of in quantitative terms as the lowest degree of human mental development. The problem of such qualitative differences as may exist within the mental range of idiocy is a problem for future investigation. This problem is touched upon in the present study only as qualitative differences appear in connection with the genetic scales employed.

Until comparatively recently the general ability of idiots in terms of mental age has been determined by the tests of the original Binet scale. More recently these abilities have been determined by the Kuhlmann-Binet, either as part of the entire Kuhlmann scale or by substituting the first two years of the Kuhlmann scale for the early tests of Binet as part of the Stanford-Binet scale. The genetic scales of Stutsman and Gesell provide a wider range of genetic measurement for these subjects. The comparative values of these scales is one question raised in the present study.

The original plan of this investigation was merely to examine a group of idiots with these three scales and compare the results with the normal standardization, our primary purpose being at that time to compare genetic aspects of idiocy with measurements of adaptive behavior employing the problem-solving technique previously used with anthropoids. As our study progressed it seemed advisable that we should make an intensive study of our results and should do this by comparing the genetic development of these idiots with that of a control group of normal subjects under the same laboratory conditions. This would enable us to evaluate our comparatively small group of subjects not only in terms of the general statistical standards for these scales, but also with the individual performances of normal children of the same sex whose life ages fell within the same range as the Kuhlmann-Binet mental ages of the idiot groups.

Subjects

Idiot Group. The idiot subjects of this investigation included 12 boys, at The Training School at Vineland, classed as of idiot

grade. Complete case histories of these children are on file at the Vineland Laboratory. For present purposes the diagnoses of idiocy are assumed to be authoritative, being based on the complete syllabus of clinical psychology. More precisely, these subjects are high-grade idiots and nearly half of them are at the borderline of low-grade imbecility. It is, however, very improbable that there will be any appreciable further mental development in these subjects. According to Kuhlmann-Binet mental age scores, this will most certainly not exceed 3.5 years.

A brief description of these subjects, showing age, mental age, average age for height (Smedley norms), and physical stigmata, is contained in Table 1. It will be noted that three of the subjects are below average in height. Descriptions of the individual children follow, based on observation in cottage, kindergarten, experimental situations, and reactions during the examination.

Johnny, physically and mentally the youngest child of the idiot group, is also the most helpless. He drools and sucks his thumb unless constantly supervised. He is not clean in personal habits, and can scarcely feed himself. His black hair and eyes, fair waxlike skin, and infantile manner make him the recipient of much attention.

TABLE 1
DESCRIPTION OF IDIOT SUBJECTS

No.	Name	Life age in yrs.	Mental age (Kuhlmann-Binet) in mos.	Standing ht. Cm.	Av. age in years*	Other data
1	Johnny	7.3	19	114	7	macrocephalic
2	Harry	10.8	20	129	10	speech defect
3	Gus	10.4	20	129	10	functionally deaf
4	Timmie	10.9	26	133	11	thyroid deficiency
5	Buster	10.6	30	139	12	cleft palate
6	Sammie	9.0	34	128	10	none
7	Howard	9.6	34	128	10	speech defect
8	Jackie	9.2	36	136	11	spastic gait
9	Carl	9.4	36	118	7	none
10	Eddie	13.5	38	159	15	macrocephalic
11	Willie	9.3	38	123	8	congenital lues
12	Ned	15.0	38	139	12	speech defect

*The age norms for standing height are computed from the Smedley tables of physical development (1).

His reactions are usually apathetic, although occasionally, when his desires are thwarted, he reacts by screaming tearlessly until distracted.

Harry is a hyperactive little fellow, always eager to accept any promise of change and just as eager to return to the established régime. His behavior in a controlled situation corresponds more to that which Thorndike terms random activity than does that of any of the other idiot children. He scarcely waits for instructions, but takes anything given to him, manipulating it irrelevantly but not destructively. In the cottage he is eager to help, and has learned to undress himself and another child.

Gus is a pathetic child who does not talk at all, and who is functionally deaf. Occasionally, but not often, he responds to his name. A ball or top is his chief delight, and, although he rarely made any constructive effort in performance tests, he took the material and patted or briefly manipulated it. There is usually a "far away" look in his eyes, which temporarily disappears when he is given a new toy, but returns almost immediately. If started on a simple activity, such as bouncing a ball or tapping a stick, a perseverative tendency is marked.

Timmie is very friendly and seeks attention, although when he receives it he smilingly retreats, and hangs his head. He is very cooperative, but is slow in his reactions. His verbal ability is meager, and relatively difficult verbal tests receive the same parrot-like response, "Mo daddy, mo daddy."

Buster is physically well developed. He has a cleft palate and does not talk intelligibly in spite of a mental age of 33 months, but by means of a relatively efficient sign language he is able to make simple wishes understood. Although somewhat deceitful, as evidenced by his performance when not aware of an observer, he was eager for attention and anxious to please throughout the examination.

Sammie is quick of movement, anxious to play, and well adjusted in school, cottage, and laboratory situations. His deficiency was supposedly due to a sudden arrest at two years of age, up to which time he had developed normally. This suggests that in some ways he might be expected to resemble the preschool child more than other children of this group. A subjective judgment, based on observation of his behavior, confirms this suggestion.

Howard is very dramatic and gesticulates a great deal. He says only a few words distinctly, but vocalizes continually, even when

alone. He frequently plays with an imaginary companion, to whom he directs a voluble stream of unintelligible chatter for periods of as long as ten or fifteen minutes at a time. He is subject to a chronic catarrhal condition.

Jackie is a lovable little boy, frequently spoiled because of his spastic gait, which slightly handicaps his running and playing. He is very affectionate and cooperates eagerly. There is a history of birth trauma, the only physical evidence of which is the spasticity of gait.

Carl, who is physically under-developed, is quick and agile in his movements, and cares little for approval. He rarely speaks unless questioned, and then his response is monosyllabic, with infantile articulation. During the examination he was cooperative as long as new materials were being presented, but was easily discouraged, and pouted if the examiner was insistent.

Eddie has an unusual fund of information for a child of his level. He asks questions constantly, demanding answers which must be consistent from day to day. He can often reproduce information given to him, and parts of conversations he has heard. This verbal ability, however, resulted from years of training, and is in many ways superficial. Eddie can do little or nothing helpful for himself or others.

Willie is an active little boy, very mischievous, and deceitful, but always appearing innocent and submissive. He pilfers from the other children and dominates them easily. He is so quick and sly that, after turning her back for an instant, the examiner would almost invariably find him taking pictures off the wall, putting test materials in his pocket, or leaving the room. As long as he is given undivided attention he is fully cooperative. He has a high-pitched nasal voice, which often terminates in a whine if his wishes are thwarted.

Ned is physically under-developed and anaemic. His speech is the most deficient of the group, although manually he is superior to most of the children. He is very willing and helpful in the cottage and never quarrelsome, but displays very little initiative, imagination, or constructive activity.

Normal Infant Group. The control group of normal infants consisted of 12 children from private families in Vineland, selected on the basis of life age as compared with the Kuhlmann-Binet mental ages of the idiot subjects. It was assumed that these children

would approximate the standard norms and thereby be comparable in mental age as well as life age to the mental ages of the idiot group. Examination, however, showed the normal subjects to be superior rather than average on the Kuhlmann-Binet scale This suggested a change in the basis for selection from that of life age to mental age. However, since the superiority on the Kuhlmann-Binet was offset by inferior scoring on one scale and average scoring on another, it was considered advisable to adhere to the original plan of having the life ages of the preschool group within the range of the Kuhlmann-Binet mental ages of the idiot group rather than pairing them with respect to scores on any one scale

These children were all in excellent health at the time of the examination and there was no record of serious illness or pathology other than ordinary children's diseases without notable sequelae A detailed tabulation of these subjects according to age is presented in Table 2

TABLE 2
DESCRIPTION OF INFANT SUBJECTS

No	Name	Life age in mos	Standing ht Cm.	Standing ht Av age in mos *	Physical stigmata
1	Neal	19	83	21	none
2	Richard	20	83	21	none
3	Paul	22	84	22	none
4	Bobby	23	83	21	cleft palate
5	Eddie	24	88	28	none
6	Norman	28	90	30	none
7	Clifford	33	91	31	none
8	Raymond	34	93	36	none
9	Billy	34	94	37	none
10	Robert	36	96	41	none
11	Edwin	38	94	38	none
12	Bernard	38	97	43	none

*The average age for standing height was computed from the Baldwin norms, inasmuch as the Smedley norms do not extend sufficiently low to include these children

The following brief descriptions of these subjects are based on observations at the time of the examination, supplemented by information from the mothers It will be noted that seven of these subjects are the only children in their families

Neal is the younger of two children The other child, a girl, is three years older, very quiet and well behaved Neal easily dominates the family He is shy, obstinate, and selfish among other

children, but usually affectionate and lovable among adults with whom he is familiar He was the only child of the group who was negativistic in his attitude toward the examination He wanted to control the situation and cried when any suggestion was made, or question asked. With the cooperation of the mother and an adjustment period of approximately half an hour, the examination was completed, and the child left in a good humor.

Richard is an only child. He was restless and distractible, but his attention was easily brought back to the task at hand He was easily and quickly examined, although frequently between tests he would ask, "Where's mudder?"

Paul is also an only child, chubby and very babyish in appearance His reactions were slow and stable He accepted and tried each test presented, without protest His performances within the range of his abilities were qualitatively high

Bobby, an only child, is delicate in appearance, with a slight speech defect which is reported due to a cleft palate His manual performances were slightly better than his verbal responses. He was very friendly and affectionate, and cooperated readily

Eddie is the younger of two boys. He was inclined to be reticent about the examination, and repeatedly asked to be taken for a ride He refused to remove his hat and gloves, but eagerly accepted and played with the test materials and toys. Before the end of the examination his wraps had been removed and his cooperation was beyond reproach

Norman, an only child, is a quiet, babyish little fellow with big, serious eyes. He was very attentive and apparently interested in the tests, but rarely smiled. His responses were either accurately and quickly given, or withheld entirely. He displayed no restlessness throughout the examination

Clifford was very independent and mature in his reactions He has no brothers or sisters and his behavior reflects that of the adults with whom he spends most of his time.

Raymond and Billy are twins Their responses on the Kuhlmann-Binet were identical, although Billy excelled Raymond in the manual tests of the other two scales, while Raymond excelled Billy in the verbal tests. There seemed to be equal domination between them when together, and both were friendly and cooperative when with others.

Robert is the youngest of three boys. He was eager, active, and

cooperative. He talked about the tests and often insisted on repeating them.

Edwin is an only child in a family of five adults He is high-strung, hypersensitive, and excessively active. His eagerness in verbal responses produced a slight stutter and in manual performances often lengthened the time required. He has an air of confidence and assertiveness which reflects the undivided attention he receives at home.

Bernard is also an only child He was very mature and precise in all his reactions, which were qualitatively high He accepted the test situation in a dignified manner and cooperated to the limit of his abilities.

Procedure

The three genetic scales, namely, Kuhlmann-Binet, Gesell, and Stutsman, were administered individually to each child of both groups All three scales were administered in one examination period with temporary interruptions to relieve fatigue or restlessness The order varied in consecutive examinations so that each scale received first place an equal number of times Examinations were conducted free from observation except that some of the mothers viewed the examination from another room through a one-way vision screen. The complete examination required from 30 to 60 minutes, according to the ability of the child and his attitude toward the examination Care was taken not to force the testing, all necessary precautions essential to such work being observed in the standard manner The examiner had previously two years of experience in this type of work and had demonstrated personal suitability for satisfactory work with both low-grade feebleminded and with normal infant subjects.

It is unnecessary to describe in detail the several genetic scales employed. However, the following brief comments are offered for those who may be relatively unfamiliar with these techniques

The Kuhlmann-Binet consists of a series of simple behavior habits acquired through development and training, as well as a limited number of psychomotor tests The majority of the test problems deal with normal growth and development of a psychomotor character, with some emphasis on the use of implements and the rudiments of language reaction. The tests are given very simply, and some of them may be scored by report of persons familiar with the

child's ordinary behavior. In all examinations wide-range tests were made, that is, two periods in the lower range were required with all tests passed and two periods were required in the upper range with all tests failed. The Stanford-Binet was used for years 3 and above.

The Gesell developmental scales include four major phases of development, each graded in degree These modes of development are classed as motor ability, language ability, adaptive behavior, and personal-social behavior The motor group includes such activities as walking, climbing, scribbling, drawing, and the like. The language group includes simple vocalization and the earliest stages of language. Adaptive behavior includes imitation, sensory discrimination, and comprehension of simple instructions. Personal-social behavior includes response to environment, self-help, and simple forms of constructive activity Gesell emphasizes that this classification of developmental reactions is one of convenience only and is psychologically somewhat artificial. The divisions do, however, display certain interesting differences in mode of development.

There is a developmental schedule for each age period which includes all the important responses that a child of that particular level might be expected to make These responses receive A, B, or C ratings, depending on the frequency of their occurrence at that age. Tests receiving a B rating on one schedule may receive an A rating at the preceding level and a C rating at the subsequent one. The most diagnostic tests of each level have been assembled by Gesell, for the sake of clinical convenience, into the normative summaries The four categories of behavior have been given relatively equal apportionments of tests at each age level Inasmuch as these made possible a wider age range with a smaller number of tests, and lent themselves readily to scoring in terms of months, these summaries were used in this study in preference to the complete schedules The same assemblage of tests was given to all subjects regardless of level, and there is, therefore, a great overlapping of successes and failures. The tests within the scale as well as complete scores are comparable

The Stutsman series of tests does not, strictly speaking, constitute a developmental scale in terms of spontaneous mental evolution. It consists of twenty separate tests, sixteen of which are manipulative and four of which are verbal These tests are standardized individually on the basis of time for successful performance

and number of correct responses. The tests are not yet combined so as to afford general ratings for genetic development

The scores obtained from these three scales of tests were first compared with the standard norms for these scales The individual performances of each child were then tabulated for the idiot group and for the normal infant group in order to study individual variation and qualitative differences from the general statistical norms This individualized treatment yields a much more intimate study of the resemblances between idiots and normal infants than is possible from the mere quantitative ratings in terms of absolute scores.

Presentation of Results

The experimental results obtained by the three genetic scales are presented in Tables 3, 4, and 5 A discussion of the results of each scale is followed by a general summary of the significance of the results as a whole and comparatively

Kuhlmann-Binet. The complete data obtained from the administration of the first two years of the Kuhlmann-Binet and the first four years of the Stanford-Binet are presented in Table 3 This shows the detailed successes and failures of each child in both groups for each test of the entire range It will be recalled that wide-range testing was employed which requires two years plus (success) at the lower range of the scale and two years minus (failure) at the upper range of the scale for each child These extremes of the testing range have been omitted in the table except for the upper ranges in the lower mental ages and the lower ranges in the higher mental ages. In addition to the distribution of successes and failures on each test for each child, Table 3 shows the total mental ages in months, life ages in years, IQ's, and scattering [2]

Analysis of Table 3 yields the following results:

1 The mean average mental age of the idiot group is 31 months, while the mean average mental age for the normal infant group is 37 months This show a superiority of 6 months for the normal infant group, although it was expected that the mental ages of both groups would be approximately the same (It will be recalled that the normal subjects were selected so that their life ages approximated the mental ages of the idiot subjects on the assumption that the

[2]By scattering is meant the number of years above the basal year in which tests are both plus and minus

TABLE 3

DETAILED RESULTS ON THE KUHLMANN-BINET FOR THE TWO GROUPS
Year I was passed by all subjects and all above Year VI were failed
Only those intervening years are included in this table

Idiot subjects	18 months: 1 Drinks	2 Feeds	3 Speech	4 Spits out distasteful objs	5 Recog objs in pictures	24 months: 1 Copies circle	2 Removes wrapping	3 Imitates movements	4 Points out objects	5 Obeys simple commands
Johnny	+	+	−	+	−	−	+	+	−	+
Harry	+	+	−	+	−	+	+	+	−	+
Gus	+	+	−	+	−	+	+	+	−	+
Timmie	+	+	+	+	+	+	+	+	+	+
Buster	+	+	+	+	+	+	+	+	+	+
Sammie	+	+	+	+	+	+	+	+	+	+
Howard	+	+	+	+	+	+	+	+	+	+
Jackie	+	+	+	+	+	+	+	+	+	+
Carl	+	+	+	+	+	+	+	+	+	+
Eddie	+	+	+	+	+	−	+	+	−	+
Willie	+	+	+	+	+	+	+	+	+	+
Ned	+	+	+	+	+	+	+	+	+	+
No of successes	12	12	9	12	9	10	12	12	8	12

Idiot subjects	Year III: 1 Knows last name	2 Knows sex	3 Knows parts of body	4 Pictures (3 objects)	5 Names objects	6 Repeats 3 digits	Year IV: 1 Copies square	2 Comprehension	3 Compares lines	4 Counts 4 pennies	5 Discriminates forms	6 Repeats 4 digits
Johnny	−	−	−	−	−	−	−	−	−	−	−	−
Harry	−	−	−	−	−	−	−	−	−	−	−	−
Gus	−	−	−	−	−	−	−	−	−	−	−	−
Timmie	−	−	+	−	−	−	−	−	−	−	−	−
Buster	−	+	+	−	−	−	−	+	−	−	−	−
Sammie	+	−	+	+	+	−	−	+	−	−	−	−
Howard	+	+	+	+	+	−	−	−	−	−	−	−
Jackie	−	+	+	+	+	−	−	+	−	−	−	−
Carl	+	+	+	+	+	−	−	+	−	−	−	−
Eddie	+	+	+	+	+	−	−	+	−	−	−	−
Willie	+	+	+	+	+	−	−	+	−	−	−	−
Ned	−	+	+	−	−	−	−	+	−	−	−	−
No of successes	5	7	9	6	6	0	0	7	0	0	0	0

Idiot subjects	Year V: 1 Compares weights	2 Patience	3 Definitions	1 Aesthetic comparison	5 Names colors	6 Three commissions	Year VI: 1 Knows right and left	2 Comprehension	3 Mutilated pictures	4 Counts 13 pennies	5 Recognizes coins	6 Morning and afternoon
Johnny	−	−	−	−	−	−	−	−	−	−	−	−
Harry	−	−	−	−	−	−	−	−	−	−	−	−
Gus	−	−	−	−	−	−	−	−	−	−	−	−
Timmie	−	−	−	−	−	−	−	−	−	−	−	−
Buster	−	−	−	−	−	−	−	−	−	−	−	−
Sammie	−	−	−	−	−	−	−	−	−	−	−	−
Howard	−	−	−	−	−	−	−	−	−	−	−	−
Jackie	−	−	−	−	−	−	−	−	−	−	−	−
Carl	−	−	+	−	−	−	−	−	−	−	−	+
Eddie	−	−	−	−	−	+	−	−	−	−	−	−
Willie	+	−	−	−	−	+	+	−	−	−	−	+
Ned	1	0	1	0	0	2	1	0	0	0	0	2

Idiot subjects	MA (months)	LA (years)	IQ	Stuttering
Johnny	19	7 3	22	2
Harry	20	10 8	16	2
Gus	20	10 4	16	2
Timmie	26	10 9	20	1
Buster	30	10 6	23	2
Sammie	34	9 0	32	2
Howard	34	9 6	30	1
Jackie	36	9.2	33	2
Carl	36	9 0	33	2
Eddie	36	13 5	22	5
Willie	38	9.3	35	3
Ned	33	15 0	31	4
		Averages		
No of successes	31	10 0	26	3 0

TABLE 3 (*continued*)

Infant subjects	18 months					24 months					Year III						Year IV						Year V						Year VI									
	1 Drinks	2 Feeds	3 Speech	4 Spits out distasteful objs	5 Recog objs in pictures	1 Copies circle	2 Removes wrapping	3 Imitates movements	4 Points out objects	5 Obeys simple commands	1 Knows last name	2 Knows sex	3 Knows parts of body	4 Pictures (3 objects)	5 Names objects	6 Repeats 3 digits	1 Copies square	2 Comprehension	3 Compares lines	4 Counts 4 pennies	5 Discriminates forms	6 Repeats 4 digits	1 Compares weights	2 Patience	3 Definitions	4 Aesthetic comparison	5 Names colors	6 Three commissions	1 Knows right and left	2 Comprehension	3 Mutilated pictures	4 Counts 13 pennies	5 Recognizes coins	6 Morning and afternoon	MA (months)	LA (years)	IQ	Scattering
Neal	+	+	+	+	−	−	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	20	19	105	2
Richard	+	+	+	+	+	+	+	+	−	+	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	24	20	120	2
Paul	+	+	+	+	+	+	+	+	+	+	−	−	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	28	22	127	1
Bobby	+	+	+	+	+	+	+	+	+	+	−	−	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	28	23	122	1
Eddie	+	+	+	+	+	+	+	+	+	+	−	−	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	28	24	117	1
Norman	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	38	28	136	1
Clifford	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	38	33	115	1
Raymond	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	+	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	42	34	111	2
Billy	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	+	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	42	34	111	2
Robert	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	−	+	+	−	+	−	−	−	+	−	+	+	−	−	−	−	−	−	46	36	128	3
Edwin	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	+	+	−	+	−	−	−	−	−	−	54	38	142	1
Bernard	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	−	+	+	−	−	−	−	+	60	38	158	3
																																				Averages		
No. of successes	12	12	12	12	11	11	12	12	10	12	7	7	11	6	10	7	1	4	5	3	3	4	3	1	3	2	1	3	1	0	0	0	0	1	37	29	124.	1 5

mental ages of the normal subjects would equal their life ages.) This indicates either that the Kuhlmann-Binet is too easy for the normal children or else that the normal group is selected in favor of superiority Probably both of these influences are operative. It will be noted, however, that five of the normal subjects are beyond the mental age limits of the idiot subjects and that the average IQ of the normal infants is 124 instead of 100, as anticipated. Indeed, all but one of the normal infants are above IQ 110 on the Kuhlmann-Binet.

2. The order of difficulty of the tests for the individual subjects is not one of orderly progression as might be expected on the assumption that the individual tests of the scale are arranged in order of increasing difficulty. Moreover, this order of difficulty is not the same for the feebleminded subjects as for the normal subjects, indicating certain differential difficulties within the tests for the two groups These facts may be noted by study of the total number of successes on each test for each of the two groups It will be noted that these discrepancies in the relative order of difficulty of the tests are much greater in the idiot group than in the normal infant group

3 As a corollary of this relative and differential order of difficulty of the tests, there is observed a larger scattering in the idiot group as compared with the normal infants, the average range of scattering being 1 5 age-periods for the normal group and 3 0 age-periods for the idiot group.

4. The differential order of difficulty of the tests is the most significant item with which our study is concerned. Even when these tests have been scaled in the relative order of difficulty for the subjects of this group of normal infants, there are still marked differential difficulties in the tests for the idiot group as compared with the normal infants. This comparative and differential order of difficulty is presented in Table 3*a*, which shows the order of difficulty of the tests for the normal subjects in age periods paralleled with the order of difficulty on the same tests for idiot subjects The tests which are indicated by single asterisks are those which were passed by at least three more normal subjects than idiots, the one test on which at least three idiot subjects excelled the normal subjects is indicated by two asterisks

Assuming that a test which shows a degree of differential difficulty such that at least three individuals in one group excel the performance of the other group is a significant difference, we find

TABLE 3*a*

TESTS OF THE KUHLMANN-BINET AND STANFORD-BINET ARRANGED IN ORDER OF DIFFICULTY FOR NORMAL INFANT CONTROL GROUP AND EXPERIMENTAL IDIOT GROUP

Age-period		Tests	Infants	Idiots
18 months	1	Drinks	12	12
	2	Feeds	12	12
	3	Spits	12	12
	4.	Unwraps	12	12
	5	Imitates	12	12
24 months	1	Obeys	12	12
	2	Speech	12	9*
	3	Circle	11	10
	4	Parts of body	11	9
	5	Recognizes objects	11	9
Year III	1	Points objects	10	8
	2	Names objects	10	6*
	3	Sex	7	7
	4	Last name	7	5
	5	3 digits	7	0*
	6.	Pictures (3 objects)	6	6
Year IV	1	Compares lines	5	0*
	2	Comprehends	4	7**
	3	4 digits	4	0*
	4	3 commissions	3	2
	5	Forms	3	1
	6	2 weights	3	1
Year V	1	Defines	3	0*
	2	Counts 4	3	0*
	3	Aesthetic comparison	2	0
	4	Morning and afternoon	1	2
	5	Knows right and left	1	1
	6	Copies square	1	0

six tests in which the normal subjects excel the idiot subjects, and one test in which the idiot subjects excel the normals Moreover, these differences are not due merely to the superior mental ages of the normal subjects, since half of the differences occur within the range where the tests are passed by approximately half or more of each group. The tests in which the normal subjects are superior by as many as three of the twelve subjects as compared with the idiots are (*a*) speech, (*b*) naming objects, (*c*) repeating 3 digits, (*d*) comparing lines, (*e*) repeating 4 digits, and (*f*) counting 4

TABLE 4

Gesell Normative Summaries

	Idiot subjects													Infant subjects												
	Johnny	Harry	Gus	Timmie	Buster	Sammie	Howard	Jackie	Carl	Eddie	Wallie	Ned	No. successes	Neal	Richard	Paul	Bobby	Eddie	Norman	Clifford	Raymond	Billy	Robert	Edwin	Bernard	No. successes
Motor Ability																										
Eighteen Months																										
1 Walks alone	+	+	+	+	+	+	+	+	+	+	+	+	12	+	+	+	+	+	+	+	+	+	+	+	+	12
2 Climbs chair or stair	+	+	+	+	+	+	+	+	+	+	+	+	12	+	+	+	+	+	+	+	+	+	+	+	+	12
3 Throws ball into box	+	+	+	+	+	+	−	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
4 Scribbles spontaneously	+	−	+	+	+	+	+	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
Two Years																										
1 Plays catch and toss with ball	+	+	+	+	+	+	+	+	+	+	+	+	12	+	−	+	+	+	+	+	+	+	+	+	+	11
2 Draws vertical stroke imitatively	−	−	−	−	+	+	+	+	+	+	+	+	8	−	+	+	−	+	+	+	−	+	+	+	+	9
Three Years																										
1 Creases a piece of paper imitatively	−	−	+	+	+	+	+	+	+	−	+	+	9	−	−	−	−	−	−	+	+	+	−	+	+	5
2 Draws horizontal stroke imitatively	−	−	−	+	−	+	+	+	+	−	+	−	6	−	−	−	−	+	+	+	−	+	+	+	+	7
3 Draws circle from copy	−	−	−	+	+	+	−	−	+	−	+	+	6	−	−	−	−	−	−	+	−	−	+	+	−	3
Four Years																										
1 Hooks fish in 20″ with rt. and lt. hand	−	−	−	−	+	−	−	−	+	−	+	+	4	−	−	−	−	−	−	+	−	+	+	+	−	4
2 Traces diamond path	−	−	−	−	−	−	−	−	−	−	+	+	2	−	−	−	−	−	−	+	−	−	−	+	−	2
3 Draws cross from copy	−	−	−	−	−	−	+	−	−	−	−	−	1	−	−	−	−	−	−	−	−	−	−	−	−	0
Five Years																										
1 Hooks fish 3 times in 1 minute	−	−	−	−	−	−	−	−	−	−	+	−	1	−	−	−	−	−	−	−	−	−	−	+	−	1
2 Draws triangle from copy	−	−	−	−	−	−	−	−	−	−	−	−	0	−	−	−	−	−	−	−	−	−	−	−	−	0
3 Draws prism from copy	−	−	−	−	−	−	−	−	−	−	−	−	0	−	−	−	−	−	−	−	−	−	−	−	−	0
Score in months	21	18	25	33	36	36	34	32	40	24	48	40		21	21	24	21	28	28	44	25	36	36	48	32	
Scattering	1	2	2	2	2	0	4	1	1	0	2	2		1	1	0	1	1	1	1	2	2	2	2	1	

TABLE 4 (*continued*)

GESELL NORMATIVE SUMMARIES

	Idiot subjects													Infant subjects												
	Johnny	Harry	Gus	Fannie	Buster	Sammie	Howard	Jackie	Carl	Eddie	Willie	Ned	No successes	Neal	Richard	Paul	Bobby	Eddie	Norman	Clifford	Raymond	Billy	Robert	Edwin	Bernard	No successes
LANGUAGE ABILITY																										
Twelve Months																										
1 Says 2 words besides "Dada" & "Mama"	-	-	+	+	-	+	-	+	+	+	+	-	7	+	+	+	+	+	+	+	+	+	+	+	+	12
2 Comprehends simple verbal commissions	-	+	+	+	+	+	+	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
3 Can wave bye-bye and often say it	+	+	+	+	+	+	+	+	+	+	+	+	12	+	+	+	+	+	+	+	+	+	+	+	+	12
Eighteen Months																										
1 Says 5 or 6 words	-	+	+	+	-	+	-	+	+	+	+	-	8	+	+	+	+	+	+	+	+	+	+	+	+	12
2 Comprehends simple questions	-	+	+	+	+	+	+	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
3 Says "hello," "thank you," etc	-	+	+	-	-	+	-	+	+	+	+	-	7	+	+	+	+	+	+	+	+	+	+	+	+	12
4 Points to nose, eyes, or hair	-	-	-	+	+	+	+	+	+	+	+	+	9	+	+	+	+	+	+	+	+	+	+	+	+	12
Two Years																										
1 Uses simple sentences and phrases	-	-	-	-	-	-	-	+	+	+	+	-	4	-	+	+	+	+	+	+	+	+	+	+	+	11
2 Distinguishes "in" and "under"	-	-	-	+	+	-	-	-	-	-	-	+	3	-	-	-	-	-	-	+	+	+	+	+	+	6
3 Names familiar objects	-	-	-	-	-	+	-	+	+	+	+	-	5	+	+	+	+	+	+	+	+	+	+	+	+	12
4 Points to 7 out of 10 pictures	-	-	-	+	+	+	-	+	+	-	+	+	7	-	-	-	-	-	-	+	+	+	+	+	+	6
Three Years																										
1 Uses pronouns, past, and plural	-	-	-	-	-	-	-	-	-	+	-	-	1	-	-	-	-	-	+	+	+	+	+	+	+	7
2 Distinguishes "in," "under" and "behind"	-	-	-	-	+	-	-	-	-	-	+	-	2	-	-	-	-	-	-	+	+	-	+	+	+	5
3 Names 3 objects in picture	-	-	-	-	-	+	-	+	+	+	+	-	5	-	-	+	-	-	+	+	+	+	-	+	+	7
4 Can tell simple stories	-	-	-	-	-	-	-	+	-	-	+	-	2	-	-	-	-	-	-	+	-	-	+	+	-	3
Four Years																										
1 Repeats twelve syllables	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	0
2 Distinguishes 4 prepositions	-	-	-	-	+	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	+	-	+	2
3 Uses descriptive words with pictures	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	+	-	-	-	-	1
Five Years																										
1 Defines words by use	-	-	-	-	-	-	-	+	-	+	+	-	3	-	-	-	-	-	-	-	-	-	+	+	+	3
2 Knows 3 or 4 words in vocabulary list	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	0
3 Interprets humor	-	-	-	-	+	-	-	-	+	-	-	-	2	-	-	-	-	-	-	-	-	-	+	+	-	2
4 Speaks with non infantile articulation	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	+	-	1
Score in months	10	16	16	24	30	24	14	31	28	30	34	17		20	21	24	21	21	27	36	37	30	43	45	40	
Scattering	1	2	1	2	6	2	2	4	4	4	4	3		1	1	2	1	1	2	0	2	1	3	2	3	

TABLE 4 (*continued*)

GESELL NORMATIVE SUMMARIES

	Idiot subjects													Infant subjects												
	Johnny	Harry	Gus	Tommie	Buster	Sammie	Howard	Jackie	Carl	Eddie	Willie	Ned	No. successes	Neil	Richard	Paul	Bobby	Eddie	Norman	Clifford	Raymond	Billy	Robert	Edwin	Bernard	No. successes
ADAPTIVE BEHAVIOR																										
Eighteen Months																										
1 Builds block tower imitatively	—	+	+	+	+	+	+	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
2 Places circular block in formboard	—	—	—	+	+	+	+	—	+	—	+	+	7	+	+	+	+	+	+	+	+	+	+	+	+	12
3 Accepts 4th cube and retains 3	—	+	+	+	+	+	—	+	+	+	+	+	10	+	+	+	+	+	+	+	+	+	+	+	+	12
Two Years																										
1 Builds block tower of 3 or more	—	+	+	+	+	+	+	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
2 Places 3 blocks in formboard	—	—	—	+	+	+	—	—	+	—	+	+	6	—	—	—	+	+	+	+	+	—	+	+	+	8
3 Folds paper once imitatively	—	—	—	+	+	+	—	+	+	—	+	+	7	—	—	—	+	—	+	+	+	+	+	+	+	8
Three Years																										
1. Builds block tower of 4 or more	—	—	—	+	+	+	+	+	+	+	+	—	8	—	—	+	+	+	+	+	+	+	+	+	+	10
2 Builds bridge imitatively	—	—	—	—	+	+	—	+	+	+	+	+	7	—	—	—	—	—	—	+	+	+	+	+	+	6
3 Discriminates between 2 short lines	—	—	—	—	—	—	—	—	—	—	+	—	1	—	—	—	—	—	—	—	+	+	+	+	+	5
4 Combines 2 parts of severed picture	—	—	—	—	+	—	+	—	+	—	+	+	5	—	—	—	—	—	—	—	—	+	+	—	+	3
Four Years																										
1 Folds paper diagonally	—	—	—	—	—	+	—	+	+	+	—	—	4	—	—	—	—	—	—	+	+	+	—	+	—	4
2 Draws 3 completions of incomplete man	—	—	—	—	—	—	—	—	+	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	0
3 Completes patience picture	—	—	—	—	+	—	+	—	+	—	+	—	4	—	—	—	—	—	—	+	—	—	—	—	+	2
4 Puts 2 blocks in cup	—	—	—	—	—	—	—	—	+	—	—	+	2	—	—	—	—	—	—	—	—	+	—	+	+	3
Five Years																										
1 Completes 4 of 8 forms	—	—	—	—	—	—	—	—	+	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	0
2 Discriminates weights	—	—	—	—	—	—	—	—	—	—	—	+	1	—	—	—	—	—	—	—	+	+	—	—	—	2
3 Performs 3 commissions	—	—	—	—	—	—	—	—	—	—	+	+	2	—	—	—	—	—	—	—	—	—	+	+	—	2
Score in months	12	20	20	27	36	33	27	29	49	27	43	41		20	20	23	27	25	27	36	40	44	40	43	42	
Scattering	0	2	2	1	2	2	4	4	3	4	2	3		1	1	2	1	2	1	2	3	4	2	3	1	

TABLE 4 (*continued*)

GESELL NORMATIVE SUMMARIES

	Idiot subjects													Infant subjects												
	Johnny	Harry	Gus	Jimmie	Buster	Sammie	Howard	Jackie	Carl	Eddie	Willie	Ned	No. of successes	Neal	Richard	Paul	Bobby	Eddie	Norman	Clifford	Raymond	Billy	Robert	Edwin	Leonard	No. of successes
PERSONAL SOCIAL BEHAVIOR																										
Eighteen Months																										
1 Uses spoon without much spilling	+	+	+	+	+	+	+	+	+	+	+	+	12	+	+	+	+	+	+	+	+	+	+	+	+	12
2 Bowel control practically established	—	+	+	+	+	+	—	+	+	+	+	+	10	+	+	+	+	+	+	+	+	+	+	+	+	12
3 Shows dramatic mimicry in play	—	—	—	+	+	+	+	+	+	+	+	+	9	+	+	+	+	+	+	+	+	+	+	+	+	12
4 Habitually inhibits certain acts	—	+	+	+	+	+	+	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
5 Tries definitely to put on shoes	—	+	+	+	+	+	+	+	+	+	+	+	11	+	+	+	+	+	+	+	+	+	+	+	+	12
6 Plays combiningly with cup and cube	—	+	+	+	+	+	—	+	+	+	+	+	10	+	+	+	+	+	+	+	+	+	+	+	+	12
Two Years																										
1 Bladder control established	—	+	+	+	+	+	—	+	+	+	+	+	10	+	+	+	+	—	+	+	+	+	+	+	+	11
2 Listens to stories with pictures	—	—	—	+	+	+	+	+	—	+	—	+	7	—	—	—	—	—	+	+	+	+	+	+	+	7
3 Tells experiences	—	—	—	—	+	+	—	+	+	+	+	—	6	—	—	—	+	+	+	+	+	+	+	+	+	9
4 Asks for things at table by name	—	—	—	—	+	—	—	+	+	+	+	—	5	—	—	+	+	+	+	+	+	+	+	+	+	10
5 Likes to play in sand filling and emptying	—	+	+	+	+	+	+	+	+	+	+	+	11	—	+	+	+	+	+	+	+	+	+	+	+	11
Three Years																										
1 Can open door	+	+	+	+	+	+	+	+	+	+	+	+	12	—	+	+	+	+	+	+	—	—	+	+	+	9
2 Can carry breakable objects	—	—	—	—	+	+	+	+	+	—	+	+	7	—	—	+	—	—	—	+	+	+	+	+	+	7
3 Asks questions of elders	—	—	—	+	+	—	+	+	+	+	+	—	7	—	—	+	+	+	+	+	+	+	+	+	+	10
4 Puts on shoes	—	—	—	+	+	—	—	+	+	—	+	+	6	—	—	—	—	—	—	+	+	+	+	+	+	6
Four Years																										
1 Uses building material constructively	—	—	—	+	+	+	—	—	+	—	+	—	5	—	—	—	—	—	—	—	—	—	—	+	—	1
2 Buttons clothes	—	—	—	—	+	—	—	—	+	—	+	+	4	—	—	—	—	—	—	—	—	—	—	—	—	0
3 Goes on errands outside house	—	—	—	—	+	—	—	—	—	—	+	+	3	—	—	—	—	—	—	—	—	—	+	+	—	2
4 Washes self	—	—	—	—	—	—	—	—	—	—	+	—	1	—	—	—	—	—	—	+	—	—	—	+	—	2
Five Years																										
1 Draws recognizable man and tree	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	0
2 Laces shoes	—	—	—	+	—	—	—	—	—	—	+	+	3	—	—	—	—	—	—	—	—	+	—	—	—	1
3 Puts on hat and coat alone	—	+	+	—	+	+	+	+	+	—	+	+	9	—	—	—	—	—	—	—	—	—	—	—	+	1
4 Uses play material with advanced constructiveness	—	—	—	—	—	—	—	—	—	—	+	—	1	—	—	—	—	—	—	—	—	—	—	—	—	0
5 Replaces material in box neatly	—	—	—	—	—	—	—	—	—	—	—	+	1	—	—	—	—	—	—	—	—	—	—	—	—	0
Score in months	16	25	25	36	47	34	29	36	43	30	54	44		19	23	31	29	28	30	39	33	34	39	45	37	
Scattering	3	5	5	4	2	4	5	2	4	1	4	4		1	2	2	2	2	1	1	1	3	1	1	2	
Final Gesell Scores	15	20	22	30	37	34	26	32	40	30	45	35		20	21	26	24	26	28	39	34	36	40	45	38	

pennies. The one test on which the idiot subjects excel is that of language comprehension in Year IV

It is therefore evident that on the Kuhlmann-Binet the important difference between these idiot subjects and this control group of normal infants is in the use of language, the idiots excelling the normal infants in one test of language comprehension, while the normal infants excel the feebleminded in use of language. These conclusions are in substantial harmony with the results of other studies in this general field

Gesell Normative Summaries. The complete Gesell data are presented for both groups in Table 4 The lower extremes of the scale, which all the children completed perfectly, are omitted Motor ability, adaptive behavior, and personal-social behavior begin at the eighteen-month level, and language records begin at twelve months. In addition to the distribution of successes and failures, Table 4 gives the estimated scores and the number of age periods over which the individuals scattered[3] for each category, the final scores, and the number of successes on each test.

These same data are also presented in supplementary Tables 4*a*, 4*b*, 4*c*, and 4*d*, which summarize related information and indicate the following results.

1 The average mental age[4] of the idiot group on the Gesell scale is 30 months, while that of the normal infant group is 31 months (Table 4*a*) This indicates a relative equality between the two groups on this scale as compared with a six-months' superiority of the normal infant group on the Kuhlmann-Binet scale This equalizing was the result of a drop in the scores of the normal infant group and was accompanied by relatively little change in the scores of the idiot group Such results suggest that the Gesell scale was relatively more difficult for this group of normal infants than was the Kuhlmann-Binet scale

2 The scores on the four categories within the Gesell scale (Table 4*a*) show a differential difficulty of as much as twelve months among idiot subjects and one or two months among normal infants. The greatest deficiency for the idiots is in language ability, while their best score falls in the group termed personal-social behavior.

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[3]See footnote 2.

[4]The final Gesell score is an average of the estimated categorical scores

TABLE 4a

AVERAGE GROUP SCORES IN THE FOUR CATEGORIES OF BEHAVIOR AND ON THE ENTIRE SCALE

	Scores in months				
	M	L	A.	P S	Av
Idiot group	32	23	30	35	30
Normal infant group	30	30	32	32	31

M—motor ability. L—language ability. A—adaptive behavior P S—personal-social behavior.

This under-development of language is relatively consistent in the idiot group. Table 4b, which gives relative ranking of individual subjects in the four categories, shows that ten of the idiot subjects rank lowest in language, while only five of the normal infants do likewise Returning to the complete data (Table 4), it will be noted that in practically every case the difference between the scores of the various categories for normal infants is slight as compared with the difference in the scores of the idiot subjects.

TABLE 4b

RELATIVE RANK OF THE INDIVIDUAL SUBJECTS OF BOTH GROUPS IN THE FOUR CATEGORIES

	Idiots					Infants			
Name	M	L	A	P S	Name	M	L	A	P S
Johnny	4	1	2	3	Neal	3	2	2	1
Harry	2	1	3	4	Richard	2	2	1	3
Gus	3	1	2	3	Paul	2	2	1	3
Timmie	3	1	2	4	Eddie	3	1	2	3
Buster	2	1	2	3	Bobby	1	1	2	3
Sammie	4	1	2	3	Norman	2	1	1	3
Howard	4	1	2	3	Clifford	3	1	1	2
Jackie	3	2	1	4	Raymond	1	3	4	2
Carl	2	1	4	3	Billy	3	1	4	2
Eddie	1	3	2	3	Robert	1	4	3	2
Willie	3	1	2	4	Edwin	3	2	1	2
Ned	2	1	3	4	Bernard	1	4	3	2

TABLE 4*c*

Average Number of Age-Periods over Which the Groups Scattered in Obtaining Their Scores in Each Category

	M	L	A	P S	Av
Idiot group	1 5	3 0	2.5	3 5	2 6
Normal infant group	1 3	1 5	2 0	1 5	1 6

3 As a supplement of this differential order of difficulty between the scores of the different categories there is also observed a larger scattering of successes within each category for the idiot subjects as compared with the normal infants As shown in Table 4*c*, this scattering of the idiot group in the different categories ranges from 1.5 to 3.5 age-periods as compared with a range of from 1.3 to 2 0 age-periods for the normal infants

4 As in the treatment of the Binet data, we assumed that those

TABLE 4*d*

Tests in Which One Group Excels the Other by Three or More in Number of Successes

	No Successes Idiots	Infants
Motor		
3 years — creases paper imitatively*	9	5
3 years — draws circle from copy*	6	3
Language		
9 months — says 2 words besides "Dada" and "Mama"	8	12
18 months — says 5 or 6 words	9	12
18 months — points to nose, eyes, or hair	9	12
2 years — distinguishes "in" and "under"	3	6
2 years — uses simple sentences	4	11
2 years — *names familiar objects*	5	12
3 years — uses pronouns past and plural	1	7
3 years — distinguishes "in," "under," and "behind"	2	5
Adaptive		
18 months — places circular block in formboard	7	12
3 years — discriminates between 2 short lines	1	5
Personal-Social		
18 months — shows dramatic mimicry in play	9	12
2 years — tells experiences	6	9
2 years — asks for things at table by name	5	10
3 years — can open door*	12	9
3 years — asks questions of elders	7	10
4 years — uses building material constructively*	5	1
4 years — buttons clothes*	4	0
5 years — puts on hat and coat alone*	9	1

tests which show a degree of differential difficulty such that at least three individuals of one group excel the performance of the other group showed a significant difference Table 4*d* lists these tests, among which are six on which the idiot excels and fifteen on which the normal infant excels. Eight of the fifteen tests favoring the normal infant are in the language group Five others involve the use of language in an adaptive form, while two involve discrimination (differences between two short lines, and placing circular block in formboard). Three of the six tests on which the idiots excel may depend on training and experience Among these are opening a door, buttoning clothes, and putting on hat and coat. The remaining three, creasing a paper imitatively, drawing a circle from copy, and using building material, are tests of manipulation

These data obtained from the Gesell scale therefore confirm the previous suggestions (*a*) that there is a greater language handicap among idiots as compared with infants of approximately the same mental level, and (*b*) that they obtain their scores from a wider range of tests, showing uneven development. Aside from the confirmation of these suggestions, we may add that the idiot group tends to be most successful in performances requiring manual ability and those which might be considered the result of their longer years of training It is also evident that on the gross scores of the Gesell scale the two groups were more nearly equal, having average mental ages of 30 and 31 months for the idiots and normal infants, respectively

Stutsman Series The relative language deficiency among idiots, which had been suggested by the Kuhlmann-Binet data, was confirmed appreciably by an analysis of the Gesell data. Inasmuch as the Stutsman is primarily a series of performance tests, it was expected that it would in like manner shed light on the suggestion of manual superiority brought forth by the Gesell data.

The results on this series of tests is presented for both groups in Table 5 A mental age score is given for each test, and, inasmuch as the standardization varies, the number of successes rather than an average score is given for each subject The number of each group succeeding and the median scores of this number are given for each test Analysis of these data show the following results

1. The number of idiot subjects succeeding on each of the 16 performance tests either equalled or exceeded the number of suc-

TABLE 5
Scores of the Two Groups on the Stutsman Series

Standardization in months	Performance tests Group 1 18-30					Group 2 30-66				Group 3 36-66			Group 4 42-66			Group 5 48-66	Language tests Group 1 18-30			Group 2 30-66	
Idiot subjects	1. Color cubes	2 Nest of cubes	3 Peg board A	4 Peg board B	5 One button	6 Two buttons	7 3 cube pyramid	8 Puzzle No 1	9 Pink tower	10. Four buttons	11 6 cube pyramid	12 Mare and foal	13 Puzzle No 2	14 Puzzle No 3	15 Manikin test	16 Matching game	1 Words	2 Word groups	3 Comprehension	4 Action agents	No. of successes
Johnny	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Harry	—	—	24	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Gus	30	30	24	30	—	—	36	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Timmie	30	30	30	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Buster	30	30	30	30	30	66	66	54	60	54	60	48	66	54	48	—	—	—	18	—	16
Sammie	30	30	30	30	30	30	60	66	66	42	36	—	66	—	48	—	30	24	24	—	16
Howard	30	30	30	30	30	36	30	—	—	36	—	—	—	—	—	—	—	—	—	—	8
Jackie	30	30	30	24	30	30	66	30	66	—	—	—	—	—	—	—	30	24	30	30	13
Carl	30	30	30	30	30	42	60	54	48	—	66	—	66	54	54	—	30	30	30	—	16
Eddie	30	30	24	24	30	30	—	—	—	—	—	—	—	—	—	—	24	30	30	42	10
Willie	30	30	30	30	30	66	60	—	42	48	48	48	—	—	36	48	30	30	30	36	17
Ned	30	30	18	24	30	66	42	30	42	66	48	36	—	—	48	54	—	—	—	—	14
Median	30	30	30	30	30	46	60	54	57	48	48	48	66	54	48	51	30	30	30	36	
No of successes	10	10	11	11	8	8	8	5	6	5	5	3	3	2	5	2	5	5	6	3	

TABLE 5 (*continued*)

Standardization in months	Performance tests: Group 1, 18-30					Group 2, 30-66				Group 3, 36-66			Group 4, 42-66			Group 5, 48-66	Language tests: Group 1, 18-30			Group 2, 30-66	
	Color cubes	Nest of cubes	Peg board A	Peg board B	One button	Two buttons	3 cube pyramid	Puzzle No 1	Pink tower	Four buttons	6 cube pyramid	Mare and foal	Puzzle No 2	Puzzle No 3	Manikin test	Matching game	Words	Word groups	Comprehension	Action agents	No of successes
Normal infant subjects	1	2	3	4	5	6	7.	8	9	10	11	12.	13.	14	15	16	1	2	3	4	
Neal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18	—	—	—	1
Richard	24	—	18	—	—	—	—	—	—	—	—	—	—	—	—	—	24	24	—	—	4
Paul	30	—	24	18	—	—	—	—	—	—	—	—	—	—	—	—	30	24	24	—	6
Bobby	—	—	18	24	—	—	—	—	—	—	—	—	—	—	—	—	18	—	24	—	4
Eddie	30	30	24	30	—	—	—	—	—	—	—	—	—	—	—	—	30	24	24	—	7
Norman	30	30	30	30	—	—	—	—	—	—	—	—	—	—	—	—	30	24	24	—	7
Clifford	24	24	30	30	—	—	—	—	—	—	—	—	—	—	—	—	30	30	30	33	8
Raymond	30	30	18	24	—	—	—	—	—	—	—	—	—	—	—	—	30	30	30	30	9
Billie	30	30	18	30	30	30	30	30	36	—	—	—	—	—	—	—	30	30	30	—	12
Robert	30	30	30	30	30	—	48	48	48	—	—	—	—	—	—	—	30	30	30	48	12
Edwin	30	30	24	30	30	—	36	36	—	—	—	—	—	—	—	—	30	30	30	66	11
Bernard	30	30	24	30	30	30	48	30	—	—	—	—	—	—	—	—	30	30	30	48	12
Median	30	30	24	30	30	30	42	33	42								30	30	30	48	
No of Successes	10	8	11	10	4	1	4	4	2	0	0	0	0	0	0	0	12	10	10	5	

among the normal infants. They asked questions about objects in the room, and talked about the test as they worked The idiot children, on the other hand, rarely spoke except when spoken to, and seldom displayed any imaginative tendencies with respect to the test materials

The normal children seemed to recognize their own limitations more quickly than did the idiot children Once having found a task too difficult, no amount of urging could persuade them to continue their efforts The idiot child, however, could often be urged to continue trying regardless of the apparent futility of his efforts This may be an indication either of superior self-criticism among the normal children, or of impatience to proceed to the next task. There is, of course, no means of ascertaining whether or not those children who gave up could have succeeded with continued effort

General Conclusions

The final results on the three scales tended, on the whole, to supplement and confirm each other, although, due to the difference in emphasis, there was a disparity in the respective group scores Analysis of the data yields the following conclusions.

1 The Kuhlmann-Binet favored the normal infants, who obtained an average mental age of 37 months and a range of from 20 to 60 months, while the average age of the idiot children on this scale was only 31 months, with a range of from 19 to 38 months. The Gesell score averages were 30 and 31 months, with the range for the idiot group from 15 to 45 months and for the normal infants from 20 to 45. On this scale the gross scores approximated equality. On the third scale, the Stutsman, the idiot group displayed a marked superiority in the performance tests, both in number of children passing the tests and in the scores obtained

2. Scattering of abilities among the subjects of the idiot group was evident from the three sets of data. Even on those tests in which the results were comparable, an analysis indicated that the idiot child obtained his score from a wider range of tests than did the normal infant. The Gesell scale was the most satisfactory in exposing the special abilities and disabilities which accounted for the child's score. The categorical division of this scale into motor ability, language ability, adaptive behavor, and personal-social behavior, made possible a numerical score in each division These scores displayed a decided

disability in language among the idiot subjects and a slight superiority in tests involving manipulatory skill

3 Language disability among the idiot group was further borne out by the Kuhlmann-Binet, on which the first failures were on tests of this nature The four Stutsman language tests also show an inferiority of the idiot group which tends to confirm this particular deficiency It must be pointed out, however, that this shortcoming in the development of language is more serious with respect to verbal expression than to comprehension In the latter the idiot children are practically equal with the normal infants of the same mental age

4 Manual superiority of the idiot children is most clearly illustrated by the Stutsman performance tests. Rapport, comprehension of instructions, and dexterity in handling the materials, all contributed to their greater success on this type of test This is also confirmed by analysis of the type of tests passed and failed throughout the Gesell and Kuhlmann-Binet scales

Summary

1 Twelve idiot boys with life ages from 8 to 15 years and mental ages from 19 to 38 months were compared with twelve normal infant boys with life ages from 19 to 38 months.

2. The comparison was made by means of three genetic age scales, the Kuhlmann-Binet, the Gesell normative summaries, and the Stutsman series These tests were administered to each group and the results compared primarily with respect to the qualitative reactions in tests within the scale but also with respect to the gross scores

3 The results were as follows

a The idiot children displayed inferiority on the Kuhlmann-Binet scale, showing a special disability on language tests

b. There was equality in the gross scores of the Gesell normative summaries, but a much greater spread of abilities among idiots than among normal infants The idiot children showed a deficiency in language and a slight superiority in tests which may be attributed to training and experience.

c The idiot children were very much superior to the normal infants on the performance tests of the Stutsman series, revealing greater manual dexterity

4 From these results the following conclusions were drawn.

a Although gross scores are comparable, the idiot obtains his

score from a wider range of tests than the normal infant, thereby revealing a greater spread of abilities

b. Language fails to develop among idiot children in relation to their other abilities. Although they surpass the normal infant group in certain respects, they remain inferior in language ability

c The manual superiority of idiot children leads to the expectation of training possibilities which have already been demonstrated in the training of children of this grade of disability

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L'INTELLIGENCE COMPARATIVE DES IDIOTS ET DES ENFANTS NORMAUX

(Résumé)

Trois mesures de premier developpement mental, c'est-à-dire, la Kuhlmann-Binet, les "normative summaries" Gesell, et la Série de Tests d'Exécution Stutsman ont été employées avec deux groupes de sujets dont (1) douze garçons idiots âgés mentalement selon Kuhlmann-Binet de 19 à 38 mois (âges physiques de 8 à 15 ans), et (2) douze garçons normaux âges de 19 à 38 mois

Les résultats bruts ont montré que les enfants idiots sont inférieurs avec le Kuhlmann-Binet, egaux avec le Gesell, et supérieurs avec le Stutsman au groupe des enfants normaux L'analyse qualitative des tests individuels de chaque échelle a montré chez les idiots une infériorité frappante dans les tests de langage, et une supériorite dans les tests qui exigent l'habileté manuelle et dépendent du développement moteur, l'entraînement et l'expérience moteurs On a trouvé aussi une plus grande variation de capacités parmi les idiots

Selon ces résultats il semble qu'un retard sérieux de l'accroissement de l'intelligence soit le plus évident dans les fonctions du langage et que les autres capacités continuent à se développer comme fonctions de maturité et de la coordination motrice. Cependant il y a un degré remarquable de similarité dans les capacités mentales des idiots adolescents comparés aux bébés normaux laquelle suggère que l'idiotie soit essentiellement un retard de la capacité mentale générale. En vue de la rapidité de l'accroissement mental chez les enfants normaux comparés à la condition mentale relativement statique des idiots, les études expérimentales de ceux-ci sont l'équivalent de la psychogenèse de "motion lente." En vue des similarités mentales des deux groupes ceci est de la plus grande valeur pour une meilleure compréhension de l'ontogénie mentale normale.

ALDRICH ET DOLL

RELATIVE INTELLIGENZ VON IDIOTEN UND NORMALEN KLEINKINDERN

(Referat)

Es wurden drei Massstäbe der frühen geistigen Entwicklung, —namentlich die Kuhlmann-Binet Tests, die normativen Zusammenfassungen ("normative summaries") von Gesell, und die Tatserie ("Performance Series") von Stutsman, angewandt an zwei Gruppen von Vpp bestehend 1) einerseits aus 12 idiotischen Knaben deren nach den Kuhlmann-Binet Tests ermitteltes geistiges Alter sich zwischen 19 und 38 Monaten und deren Lebensalter sich zwischen 8 und 15 Jahren erstreckte, und 2) anderseits aus 12 normalen Knaben deren Lebensalter sich zwischen 19 und 38 Monaten erstreckte.

In den allgemeinen Ergebnissen erwiesen sich die idiotischen Kindern im Vergleich mit den normalen Kindern in den Kuhlmann-Binet Tests als tieferstehend, in den Gesell tests den normalen gleich, und in den Stutsman tests als überlegen. Eine qualitative Analyse der einzelnen Tests aus jeder Serie enthüllte bei den idiotischen Kindern ausgeprägte Untergebenheit in denjenigen Tests welche Sprache in Anspruch nahmen und Überlegenheit bei Tests welche Handgeschicklichkeit verlangten und sich auf motorische Entwicklung, Dressierung, und Erfahrung stützten. Die Fähigkeiten der idiotischen Kinder erwiesen auch einen weiteren Umfang ("range").

Aus diesen Ergebnissen erscheint es, dass ernste Verzögerung in der Entwicklung der Intelligenz sich am deutlichsten in den Sprachfunktionen zeigt, und dass andere Fähigkeiten sich als Funktionen der Reife und der motorischen Koordination weiterentwickeln. Es besteht nichtsdestoweniger eine merkwürdige ähnlichkeit zwischen den geistigen Fähigkeiten von heranwachsenden Idioten und denen von normalen Kleinkindern, welche andeutet, dass die Idiotie im Wesentlichen eine Verzögerung der allgemeinen geistigen Entwicklung ist. Mit Hinsicht auf die Schnelligkeit der geistigen Entwicklung bei normalen Kindern in Vergleich mit dem relativ statischen geistigen Zustand der Idioten kann man experimentelle Untersuchungen an Idioten als das Äquivalent einer langsam fortschreitenden ("slow motion") kinematographischen Schilderung der geistigen Entwicklung betrachten. Mit Hinsicht auf die ähnlichkeiten zwischen den zwei Gruppen ist eine solche Schilderung von höchstem Werte zur Förderung einer besseren Einsicht in die normale geistige Entwicklung.

ALDRICH UND DOLL

ANALYSIS OF METHODS IN HUMAN MAZE LEARNING*†

From the Psychological Laboratory of the University of Wisconsin

RICHARD WELLINGTON HUSBAND

INTRODUCTION

Numerous studies have been made on various external features of learning, especially those aspects of the learning process which may be controlled from the outside. A few illustrations are massed and distributed practice, part and whole, guidance, retention, and transfer. In comparison with these, the methods by which the learner works while at his task have, for the most part, been ignored. Warden (8) and Perrin (5) have dealt with them in fair detail, but the few others who have considered this side of behavior have given it only minor emphasis

The latter, the internal aspects of the learning process, are not any less important because of not being as self-evident as those features which are more readily controlled by an outside person. General practice has been to confront the subject with his task with little knowledge of what is to be done, and to give him no guidance as to the best methods of accomplishing it, in spite of the fact that a learner may approach the task in various ways entirely apart from the externally controlled aspects of the work periods. This is the problem dealt with here.

There are several techniques possible for studying the processes involved in learning and memorization Among these are acquisition of motor skills, prose or poetry, nonsense syllables, arithmetic, and maze learning. For several reasons the last named was chosen as the most suitable apparatus The maze gives material of a serial and connected nature, it can be constructed in unlimited combinations; it provides a situation previously unfamiliar to the learner, alternative choices are demanded, and in such a way that recognition

*Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office July 25, 1930

†The writer wishes to express his appreciation to Professor W R Miles, under whose guidance this study was carried on at Stanford University

plays but little part, it has a spatial element which is of no great consequence in this type of act, but at the same time gives objective evidence of what the learner is doing, and, lastly, the learning does not take place all at once

Problem

The general problem is a study of the methods by which humans learn a maze pattern. Some of the exact questions to be considered may be stated specifically (*a*) *Methods*: the ways in which the maze may be learned, their relative efficiencies, the development of these methods, and the effects on the learning process resulting from their adoption. (*b*) *Approach*. is the method adopted by each subject natural to him, or might he use a different one? (*c*) *Relearning* are the methods which were superior in the original learning likewise best for purposes of retaining the material learned? (*d*) *Length and Difficulty*. do the several methods of learning vary in efficiency for tasks of different degrees of difficulty?

Apparatus and Technique

The general procedure followed in this series of experiments has been previously described by the writer (2) and by Miles (4) Briefly, the apparatus consisted in a four section multiple-U high-relief finger maze The unit design followed that of Warden (8), while the pattern was built in the Miles wire-pathway method of construction. Each of the four sections was composed of ten right or left turns, and was rendered distinct from the others by means of rather long transverse connecting links By this arrangement, different lengths of pattern could be used as desired

Subjects were obtained largely from elementary classes in psychology. Four groups of 80 each learned one, two, three, and four sections.

Before starting to learn, the subject was given a brief explanation of the general nature of maze tasks, and the particular type of construction of this was described To demonstrate, he was allowed to feel over several turns of a sample section, with the blindfold in place. The blindfold used was that recommended by Miles (4), being a pair of leather goggles with adhesive tape over the lenses and a sheet of tissue between the leather goggles and the face

Record was kept of trials, errors, and time. Trials followed each other in succession until learning was completed. The criterion was

three consecutive errorless trials, or three out of four perfect attempts.

When the criterion had been satisfied, questions were asked concerning the subject's method of attacking the problem, his progress of learning, places of special difficulty, and a few other points which will be brought out in the discussion.

Results

The methods of learning fell into five groups, as listed just below. These will later be referred to by first letters only, to save table space. The first three methods may be considered qualitatively different, because they involve entirely different procedures. The other modes of attack are quantitative variations of these three.

(*C*) Counting, or verbal. The turns were remembered strictly and accurately, as, for instance, one right, three lefts, two rights, and so on. If this method was not started early in the learning process, the case was classed elsewhere.

(*M*) Motor. Learning was effected entirely without an attempt to remember the units of the pattern. First the general directions were discovered, and then more exact spatial judgments were gradually perfected. The cues were all kinaesthetic and motor; there was practically no conscious effort to organize the experiences under abstract symbols.

(*V*) Visual images of the pattern were occasionally, although rather rarely, built up.

(*C, M* 2nd) Counting, with motor or visual secondary. In the main, the pattern was learned by counting, but some parts were learned by other means, possibly a few turns in each section, or one entire section out of the several included in the task.

Miscellaneous methods were used by others, but the groups were not large enough to be classed separately.

Out of the total number of 80 in each group, the numbers using each method on each task were as shown in Table 1.

The number of subjects who learned by each method is very significant. We see that the counting procedure (*C*) includes nearly half of the total in each group, and with this basic method, plus the use of some motor elements included, we find that over half of the subjects use largely ideational means. This number increases in the longer patterns, while the motor method (*M*) is used by fewer

TABLE 1
NUMBER OF SUBJECTS LEARNING BY VARIOUS METHODS

	Method			
Sections	C	M	V	C, M 2nd
1	28	20	3	8
2	27	15	1	14
3	29	11	3	13
4	30	9	3	16

TABLE 2
TRIALS TO LEARN

			Method		
Sections	Av	C	M	V	C, M 2nd
1	16.9	10.1	25.8	15.0	16.1
2	23.6	15.1	34.4	26.0	22.7
3	26.6	18.8	40.4	34.7	23.0
4	27.7	20.4	41.2	19.7	25.0

TABLE 3
TOTAL AVERAGE ERRORS BY METHODS

			Method		
Sections	Av	C	M	V	C, M 2nd
1	35	20	23	29	33
2	89	54	147	71	86
3	156	101	277	185	124
4	218	151	466	241	181

and fewer as the task becomes longer and more difficult. The visual (V) attack is not prominent in any of the tasks

Trials to Learn The trials required to satisfy the criterion, both as grand averages and as scores for the users of the various methods, are given in Table 2 Immediately we see the advantages of using the ideational method of attack, and the general inferiority of the kinaesthetic mode of learning The former is consistently at about the first quartile of the entire group, while the motor groups are at the third quartile. Those learning by visual imagery are quite variable, all the way from among the best to the very slow in learning

Five subjects who failed to learn within two hours were dismissed Four of these had been attacking the problem by a motor method, and the other was trying to use visualization

It is evident that the difficulty of learning, in this variable at least,

does not increase proportionately with the length of material to be learned.

Errors

Total. The averages for total errors made during the whole learning process, given in Table 3, show the same general rankings as did trials to learn. The absolute figures increase much faster than did trials, since the number of blinds increase in the longer patterns, giving chances for more errors, while the trial score is, of course, only raised by one at a time regardless of whether one or four sections are being traversed. With this factor held constant, however, the agreement with trials is almost perfect.

The average total errors for the various groups are also given in this table. In learning the one section of ten turns the motor method was not much less efficient than some of the others, but with longer tasks it progressively becomes more and more of a handicap to those using it. The visual groups, in spite of the few subjects, exhibit regularity, and are somewhat inferior to the abstract learners. Visualization, like the motor procedure, seems to become very difficult in the longer tasks. The methods which were partly counting, but not wholly so, fall considerably behind those using that method alone. The extent appears (from data not presented here) to be roughly proportional to the presence of elements other than ideational.

All in all, we find the error scores to very closely resemble those of trials to learn in differentiating the various methods, in proportions, and in separating the tasks into their various degrees of difficulty.

Error curves. Are the scores for the various methods similar, so that one is consistently and proportionately inferior or superior to a second, or does this difference change as trials go on? The four groups of curves in Figure 1 show the progress of learning for those using the counting and motor attacks, as well as the general averages. In order to portray accurately improvement in equal increments the error scores were plotted on a logarithmic basis. Thus a perfectly straight line would represent steady progress.

Due to the usual minor discrepancies, no group made absolutely consistent progress, but the best possible line was drawn through each set of points. In a few cases this line has a slight angle in it. The groups using the two principal methods have lines with different slopes, those who counted making progress about twice as rapidly as those learning by kinaesthetic means. These, and curves for the

total numbers, show progress as given in Table 4. The lines for the average performances lie between those for the discrete groups, as might be expected from other data which have been presented. The proportional separation possibly increases slightly with increase in difficulty of task.

Individual errors. All choices in the maze were to the right or to the left, and arranged to make the pattern as homogeneous

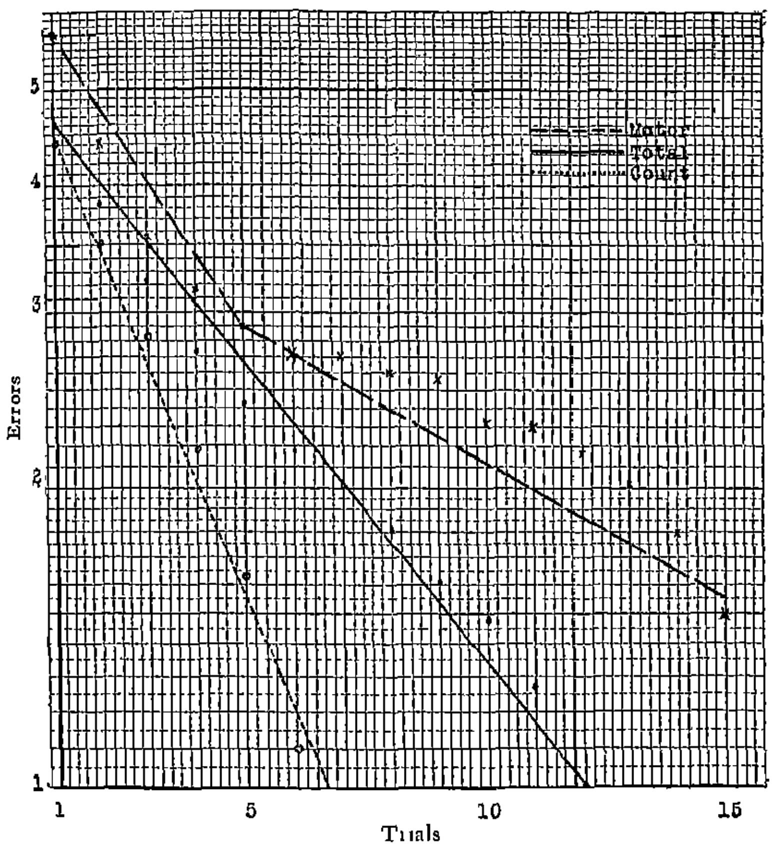

FIGURE 1
CURVES FOR THE ENTIRE GROUP AND FOR THOSE LEARNING BY COUNTING AND MOTOR METHODS
A. ONE SECTION

TABLE 4

NUMBER OF TRIALS TO HALVE ERROR SCORES

Sections	Method Av	C	M
1	4 0	2 7	7.0
2	6 1	4 0	10.5
3	7 5	4 9	16 8
4	7 0	5 0	13 0

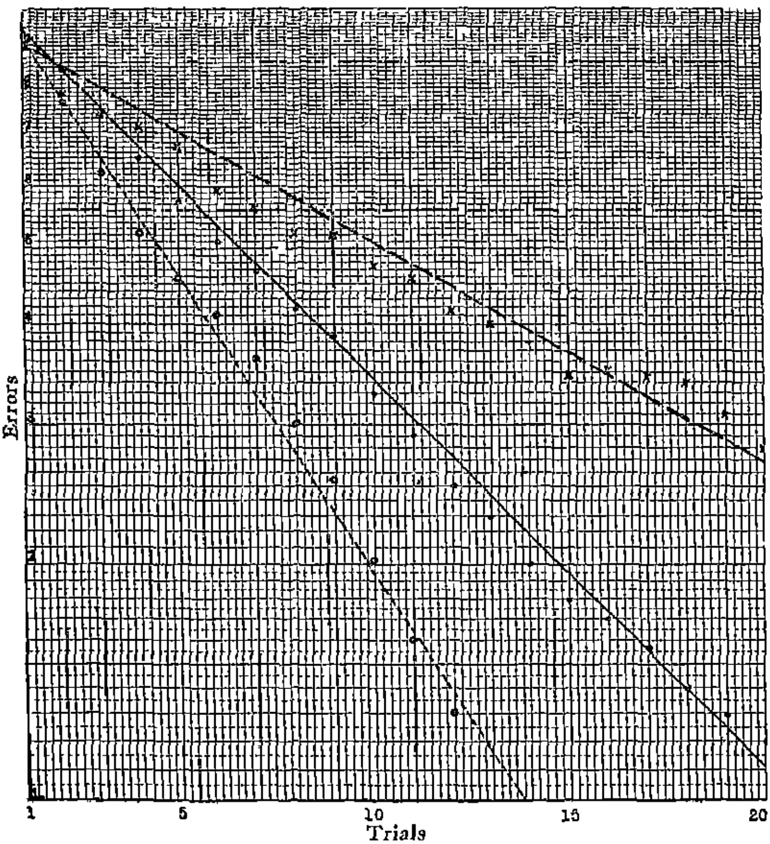

FIGURE 1 (*continued*)

B. TWO SECTIONS

as possible, and to minimize position cues Thus, theoretically, one blind should offer about the same difficulty as another But the results proved this to be far from true

The former report (2) discussed this matter at greater length and analyzed these differences. However, a few of the more important points will be briefly enumerated here (*a*) The last two sections proved to be easier to learn than the first two, hence fewer total errors were made on them (*b*) The outstanding point with regard to individual errors was the steady progression or increase in a sequence. Thus, where there are three turns in the same direction, as in Alleys 3, 5, and 7, there will be more errors made on 5 than on

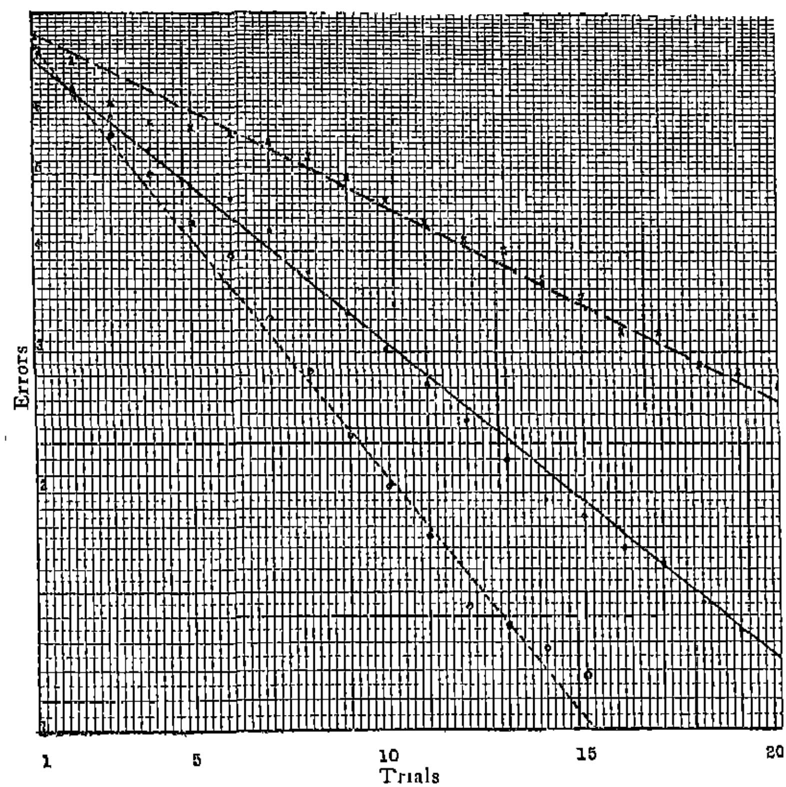

FIGURE 1 (*continued*)

C Three Sections

3, and still more on 7, but very few on 9, which breaks the sequence and goes the other way. (*c*) A turn is often taken out of its place, i.e., anticipating one that follows later.

Errors are, of course, abstractions, and may mean little by themselves, but after inspecting the averages we may see how the use of different methods affects them. In Figure 2 are given the averages for each alley for the full number of subjects, and for the count and motor groups, the figures for all sections and tasks being added together (*a*) The total number of errors made by motor learners

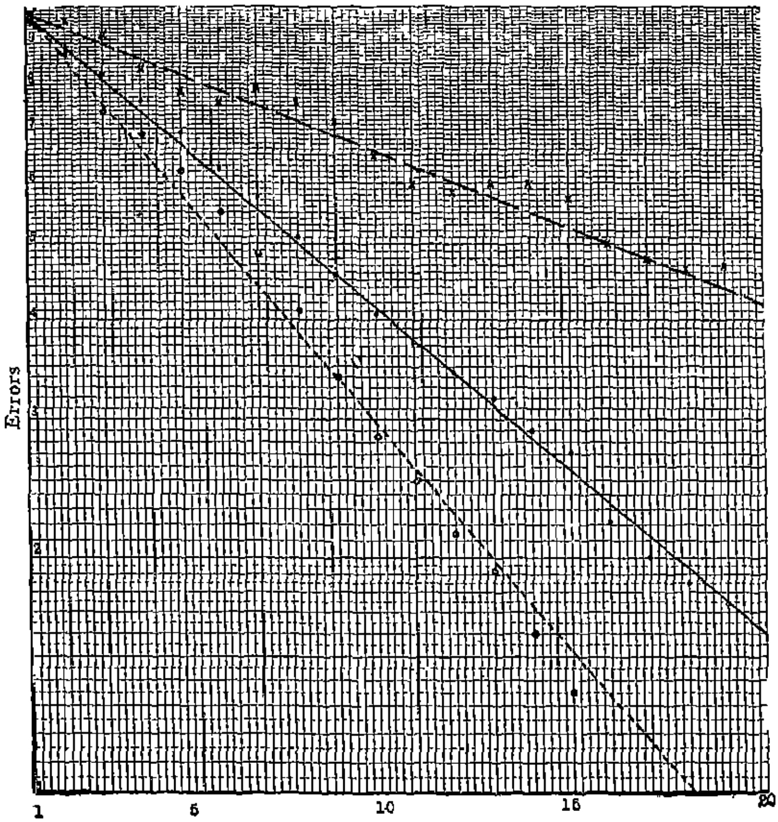

FIGURE 1 (*continued*)

D FOUR SECTIONS

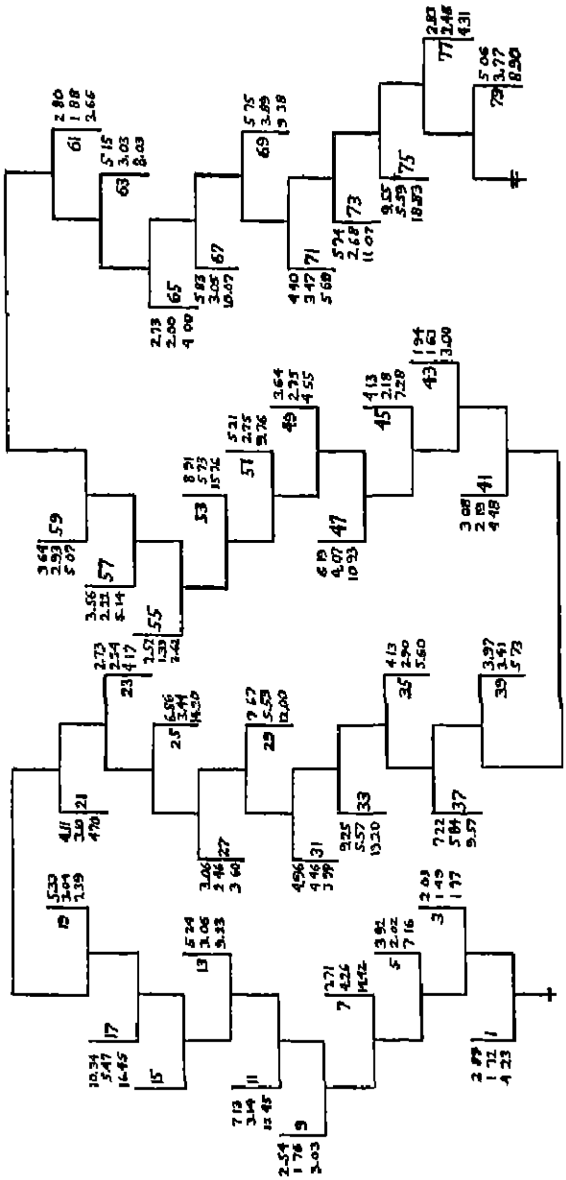

FIGURE 2

AVERAGES OF INDIVIDUAL ERRORS

Averages given for total group, count, and motor learners, respectively

on each blind is much greater than that shown by counting groups *in general*, although fewer in some cases. (*b*) In a break after a sequence the errors for the motor group are noticeably fewer. (*c*) Motor subjects make proportionately more errors in a sequence, the third members being particularly large. Many subjects who counted the turns found a long sequence, after it was once discovered, an aid rather than a point of difficulty in learning

Persistent errors Almost all subjects made errors on certain alleys for several trials in succession Such behavior was far more characteristic of the motor attack than of a counting method. Errors on five successive trials were made about three times as frequently by those using kinaesthetic attacks as by those employing abstract procedures. As many as 10 and even occasionally 20 errors in consecutive trials on the same blind were not uncommon for motor learners, but were rarely found in the other group.

Corrections All types of change of direction, ending right or wrong, predominate in the first ten trials, which would seem to indicate that change was more from indecision or doubt than from real knowledge Motor subjects made far more corrections than those learning by an abstract procedure The verbal subjects, then, appear to attack the problem in a more direct and decisive manner Further, the kinaesthetic learners were also more inaccurate in their corrections, only slightly over half the changes preventing an error, while three-fourths of those on the part of the abstract learners were correct. *Hesitation* usually implies thinking the pattern over Motor subjects exhibited this tendency very little, less than half as many instances being recorded as for the counting group In contrast to corrections, it was noticed that the occurrence of hesitation seemed to increase with perfection of learning up to a certain point, when the learner became more sure of his knowledge of the pattern.

Time Scores It is in time scores that we might expect exceptions to the very consistent results so far shown The general features of the two main methods of learning present a contrast, the counting method being slow, deliberate, ideational, and requiring few trials, while the motor attack is hasty, rather careless, with little conscious thought, and requires many trials, each of which is of short duration Table 5 gives the averages of total time consumed in learning the different patterns. In the more difficult tasks there is an increase which is somewhat more rapid than the increase in length of pattern, just as was found with errors The ratios are very close to

TABLE 5
AVERAGE TIME IN SECONDS REQUIRED TO LEARN

			Method		
Sections	*Av*	C	*M*	V	C; *M* 2nd
1	528	358	802	505	542
2	1438	1102	1972	1401	1445
3	2423	1822	2943	3785	2014
4	3150	2523	4066	1954	2707

those of the other variables, although the agreement is not quite so good as that between trials and errors

In comparing the various methods of learning, the counting approach again shows considerable superiority, the motor subjects requiring on the average almost twice as long to learn, in spite of the much more rapid pace set in each trial. Those using the visual method were too variable to generalize from the figures

The results are far more irregular than was the case with either trials or errors. However, when comparisons are made between the two main groups, the conclusions tend to agree with the former results

A fact which might somewhat narrow down the difference between these two groups is that the abstract learners took more time between trials to rest or to think over the pattern. In contrast to this, the motor learners were very impulsive, beginning the next trial as soon as one was concluded This matter is difficult or impossible to measure, however

A change of method is frequently disclosed by inspection of time records. A subject may be making trials in fairly fast time, but on a certain trial is extremely slow, after which error scores are materially reduced. This shows a change from a hasty method, usually motor, to a carefully applied ideational attack.

Order of Learning. There is so much individual variation in order of learning that trends are largely obscured In general, the first section is learned earliest Beyond this there is doubt, some figures point toward a progressive order, while others indicate that the last section is learned next, and the inside ones last Furthermore, there is a counter-tendency for the easy sections to be learned early regardless of where they are in the maze, although the position does influence the extent of this tendency

These divergences are explained by the fact that subjects who

used ideational methods tend to learn the sections as they come to them, the initial one first, etc , while the motor learners learn more in order of ease of the individual sections.

Relation with Intelligence. How much of an index of general ability is the behavior in a learning situation of this type? Obviously, not too high correlations are to be expected, since at best this act can be regarded as only one test in a battery, and so not perfectly indicative of the whole level of ability.

Intelligence scores were available for about two-thirds of the total number. The correlations are given in Table 6. In each group the first figure denotes correlation with the total number included, the second and third coefficients are for those in the count and motor groups, respectively "*X*" signifies too few cases to make satisfactorily reliable figures.

These figures were considerably lower than had been expected What was most surprising was that the two easiest tasks uniformly correlated higher with intelligence than the more difficult ones. It seems fairly reasonable that the low coefficients for the entire groups are largely due to the disparity in methods by which subjects learn. Following from this, a probable explanation of the low correlations in the more difficult tasks is that the two methods were more thoroughly differentiated than in the easier problems, making a sort of bimodal distribution in the correlation plots When subjects, all of whom learned the same way, are segregated, the coefficients are raised materially, in spite of the theoretical possibility of lowering the figures by using a more homogeneous group in each case Possibly in this way we get results much closer to the real learning ability. There is also shown some tendency toward increase of correlation with difficulty of the task.

What little difference does exist in the average intelligence scores of those learning by different methods favors those using an abstract

TABLE 6
CORRELATIONS OF MAZE PERFORMANCE WITH INTELLIGENCE SCORES

	Trials			Errors			Time		
Sections	Av	C	M	Av.	C	M	Av	C	M
1	.37	.60	18	33	.60	.13	.43	.82	41
2	45	.05	x	38	29	x	59	40	x
3	10	29	.78	08	49	.78	.22	61	.80
4	.19	46	60	12	38	.50	20	32	80

procedure However, all means are within a fraction of a standard deviation of each other, and the probabilities of the differences being significant are barely beyond chance.

Reliabilities. The reliabilities of the maze patterns, as computed by the odd-even error method, using data from the sixth through the fifteenth trial, range from .84 to 95, with the longer patterns having the higher coefficients, as might be expected These figures are very satisfactory and guarantee accurate results There are no appreciable differences between the persons learning by the counting and by the motor methods.

Transfer

For several reasons it was decided to test the learning of a second pattern (*a*) to see how much actual improvement in scores would be shown; (*b*) to discover if the methods would remain the same, or whether subjects might adopt more efficient methods after having learned one pattern by what possibly might be termed their "natural" method, (*c*) general vs specific transfer, two types of mazes, one similar to the first, and the other employing different cues, were used The former is termed Section V, and is a high relief maze of ten turns with a new pattern; while the latter is a stylus maze, the pattern being that of Section I of the large maze

Twenty-four subjects out of the group of 80 which learned three sections of the finger maze were asked, after finishing, to learn Section V. Twenty more subjects learned the Section V first and the stylus maze second. Thus the second group acted as controls for the first, in that they learned Section V as a problem entirely new The stylus group had as their controls an additional group of 20 who learned this maze as a separate and original task

The same instructions and conduct of testing as in other parts of the study were observed here.

General Results Summary of the results is given in Table 7 The first fact evident is that far more profit is derived when the learner passes on to an identical task than to one that is somewhat different. The savings in trials, errors, and time are largely in agreement, there always being more saved when transfer is to a pattern of identical construction.

As to individual errors, the effect of sequences still seems to operate on the second pattern, but to a decreased extent

Effect of Transfer on Methods Are more efficient methods used

TABLE 7
EFFECTS OF TRANSFER, OR PRACTICE

Task	Trials	Errors	Time
V first	15.9	29.5	560
V second	7.2	11.4	157
Stylus first	23.1	54.2	736
Stylus second	16.3	33.6	554

on a second problem? The counting and motor methods, as used in pure form, gain in numbers over the other means of learning on the second test. Further, more change to the verbal group than to the motor—a less efficient—method. As to quality of performance, the pure motor learners profited more in absolute figures by having already learned one maze than did the pure counters, but of course there existed more room for improvement in the former.

In going to a new pattern the attack on the problem seemed direct and efficient. But in changing to a stylus task from a finger performance a new orientation had to be made, in spite of the fact that the shape of the blinds and the general manner of construction of the two mazes, aside from the subject's means of contact, were identical. In fact, learning on this pattern was only a third better than the scores of subjects who learned this maze with no previous maze practice. And the improvement was only approximately a third of that made in transferring to an identical task.

Retention

Another fundamental question is whether fewer repetitions by a highly abstract method will bring about learning as permanent as that of a motor subject who has gone over the pathways many more times in the original learning period.

A total of 21 subjects from the group learning the two-section patterns were tested for retention after a lapse of a week. These were selected from the whole group because of having used certain typical methods. About two-thirds of this group originally learned either by pure count or pure motor means. After finishing the original learning, the subjects were not allowed to see the pattern, but the panel was turned over while they were telling how they had learned. If the method turned out to be suitable for purposes of the retention test, they were asked to come back just a week from that hour "to learn *another* maze, which will probably take not more

than a third the time it took to learn this one." The experimenter was thus careful to avoid the impression that they were to relearn the same maze

The general summary of results of this experiment is given in Table 8 Figures for the methods less frequently used are omitted, as there were too few in these groups for reliability. The majority

TABLE 8
SUMMARY OF LEARNING AND RELEARNING

	Av	C	M
1 Numbers			
Learning	21	8	5
Relearning	21	10	6
2 Trials			
Learning	24 2	13 4	43 8
Relearning	8 2	5 4	14 2
3 Errors			
Learning	93	49	177
Relearning	12	5	29
4. Time			
Learning	1448	1088	2340
Relearning	329	264	472

of subjects used the same methods in the retention test as in the original learning, exactly two thirds of the group being so recorded. As in the transfer experiment, changes were toward more pure methods, and more shifts were to a verbal method than to the less efficient motor attack

A great saving is seen in all three scores We see that the counting subjects saved even more over the motor learners in the relearning than in the first test, especially when the last three perfect trials (which play no part in the actual learning) are not counted In this case the law of frequency, which is usually invoked as the chief determiner of learning, is decidedly violated

The frequency of individual errors resembled very closely that of the original learning. The alleys which gave the most trouble in the first period invariably cropped out in the retention test However, in comparison with the original the small number of errors made in the second test is outstanding.

In general, the amount of saving was surprising both to the experimenter and to the subjects themselves Many, when told that their task was to relearn the pattern, remarked that they would really

have to begin all over again, as they could not remember a single thing But, once started on the pathway, it seemed to come back piece by piece, very few mistakes being made even on the first trial.

Discussion and Interpretation

In the first place, this study has demonstrated the need of controlling the approach or method of attack of the subject to a learning problem

As was pointed out in the introduction, there has been a good deal of attention paid to the objective or outside controlled conditions of learning, such as hours of study, part-whole, or massed-distributed practice, but the manner in which the learner goes about his task has been given less attention

Probably there are two main reasons why subjective attitudes have been neglected in studies of learning· (*a*) the assumption that methods are sufficiently alike to be ignored, and (*b*) the assumption that various approaches to a problem are natural to the subjects and that nothing can be done about them in a constructive way.

The first assumption in this case appears invalid, as evidenced by the list of methods and the numbers using each, given in Table 1. As evidence that the second possibility also is fallacious we have seen that changes of method occur during learning and in learning a second pattern Besides, there seemed to be no types of individuals who universally fell into certain methods of learning Further, we hope to show (3) that comparable groups behave differently when confronted by maze patterns of slightly different construction As a result, the writer feels that change of method is perfectly possible and practical. However, within the scope of the present study, no coaching was attempted to see if those who had never learned any maze could all profitably use a certain method. Many subjects stated that they should have counted more accurately, or started earlier, thus making a spontaneous declaration that they could use other methods.

Proper control and coaching would eliminate much of this wasted effort, which results either in eventual discard of the original method for one which might just as well have been adopted at the outset, or else in poor efficiency all the way through the learning period. Even the method which was found to be best, counting, was not perfectly applied by all who used it as a fundamental means of learning.

Much of the high variability which has always characterized maze results was found to be due to the many different methods used in

learning. Standard deviations are usually between a quarter and a half the size of their means. Each method, as employed by different learners, has its own mean, with cases clustered about it. There is, of course, a certain amount of overlapping with other groups. When we combine all the groups into one distribution there is bound to be a wide scattering. Correlations of performance with intelligence were also lowered by the discrepancy of methods. Order of learning also was seen to be somewhat confused by conflicting elements in the situation.

In brief, the outstanding differences between the two chief methods of learning are as follows: In terms of general efficiency the abstract method is superior. It is also characterized by its smooth and decisive action, while the person using the motor attack is very rapid and impulsive. Motor learners tended to alternate their choices, and so were greatly troubled on sequences of several turns in the same direction, while this did not bother those using a verbal procedure.

Comparisons with other experiments on the same topic but with different apparatuses are rather difficult, because different levels of behavior are involved.

Swift (7), in studying ball tossing, found that methods were unconsciously selected. The act is a motor skill, rather than one demanding ideational procedure, so the differences are not necessarily antagonistic to the results found here. Renshaw and Postle (6) divided subjects in a pursuit test into three groups, (*a*) uninstructed, (*b*) given general principles of action, and (*c*) taught in minute detail the best procedures. The latter group fell far behind the first two, which made about equal progress.

Gilbreth (1) has devised standardized operations in a number of occupations and thereby greatly increased efficiency; these may be considered along the same general line as the experiments discussed here. He assumed, it may be noted, that methods could be changed for the better.

SUMMARY

1. The general purpose of this investigation was to study methods of learning. To do this the following experiments were made: four groups, each of 80, learned respectively one, two, three, and four ten-turn sections of a high relief maze with U-shaped blinds, two groups of 20 and 24 subjects were tested for transfer, and 21 subjects were tested for retention.

2. There were found to be three qualitative methods of learning: verbal, visual, and motor; and different quantitative variations and combinations from these. Very few subjects were found to be in the visual class, and no great number was in any group using the mixed methods.

3. The motor approach was especially inefficient, while the counting method was by far the most superior. Those using the visual attack were highly variable in efficiency, being subject to great individual variation. The mixed methods ranked somewhere between the main methods from which they were variations. The different scores (trials, errors, and time) agreed closely with each other in ranking the methods as indicated above. There was slightly less difference in time than in the other variables, since the two most frequently used methods (verbal and motor) presented a marked contrast in this respect: the abstract learner proceeded very slowly and methodically, while the individual who attacked the problem in a kinaesthetic manner set a fast pace, and thought and planned very little. This relation between these two methods carried over into a new task (transfer) and in relearning after a period of no practice.

4. The use of different methods was found to account for high variability in scores, low correlations between performance and intelligence, and the complex trends in order of learning.

5. Methods are not invariable, as shown by changes during learning, different methods being used in learning a second pattern, and different proportions of these methods appearing in tasks with different types of mazes.

6. On the basis of these results it is urged that coaching be practiced, learners being instructed in the best procedures before work is started, in order to avoid much waste in trial-and-error attack at the beginning of learning.

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L'ANALYSE DES MÉTHODES DANS L'APPRENTISSAGE DU LABYRINTHE PAR LES ÊTRES HUMAINS

(Résumé)

On a fait cette étude dans le but de découvrir et d'évaluer les différentes approches intérieures à l'apprentissage, contrastées aux facteurs extérieurs, tels que les heures d'étude, lesquels peuvent être contrôlés par une autre personne. On a choisi le labyrinthe comme le meilleur appareil pour l'étude de ce problème. On a employé plus de 400 étudiants universitaires comme sujets, lesquels ont appris des labyrinthes de diverses longueurs, et dans diverses conditions.

On a trouvé qu'il y a eu trois methodes principales pour le commencement de la tâche par les sujets: les méthodes verbale, motrice, et visuelle. Plus que la moitié du groupe ont employé des processus verbaux en quelque forme ou autre; tres peu en ont résolu le problème par les représentations visuelles. La methode verbale s'est montrée définitivement la meilleure méthode d'attaque, mesuree par tous les trois résultats—essais, erreurs, et durée. Plus la tâche est devenue difficile, plus les méthodes ont été différentes en termes de l'efficacité. Plus d'erreurs persistentes se sont montrees avec l'attaque motrice, qui a éte essentiellement une méthode inconsciente d'apprentissage, tandis que ceux qui ont employé des suggestions verbales ont pu très vite remédier à leurs erreurs.

Les correlations du rendement dans le labyrinthe avec l'intelligence n'ont éte que moyennes, ce qui a ete dû en grande partie au fait que l'emploi des différents processus de l'apprentissage a cree une sorte de bi-modalité. Le transfert à un labyrinthe semblable a produit une économie d'environ les deux tiers du temps nécessaire pour apprendre le premier, tandis qu'il n'y a eu une economie que d'environ un quart de la premiere durée quand le deuxième labyrinthe a été très différent. Ceux qui ont appris premierement par la méthode verbale se sont rappelé plus après un delai de huit jours que ceux qui ont employe une attaque kinestésique ou motrice, malgré le fait qu'ils avaient eu moins de pratique dans la première période de l'apprentissage.

L'auteur est certain que les méthodes ne sont pas fixes, ou uniques chez l'individu, et recommande donc qu'on enseigne à ceux qui apprennent la méthode interieure, ou subjective, d'attaquer un problème aussi bien que les méthodes plus objectives.

HUSBAND

ANALYSE DER MENSCHLICHEN LERNMETHODEN BEIM ERLERNEN EINES LABYRINTHES

(Referat)

Es war das Ziel dieser Untersuchung, die verschiedenen innerlichen Annaherungsweisen dem Lernen gegenuber, im Gegensatz zu den ausserlichen Bedingungen, —Zahl und Zeit der Studierstunden u.s.w., —die durch Jemand anderem bestimmt werden konnen festzustellen und abzuwagen Das Labyrinth wurde als das beste Apparat zur Untersuchung dieses Gegenstandes gewahlt, als Versuchspersonen dienten im Ganzen uber 400 Studenten welche Labyrinthe von verschieden Längen unter verschiedenen Umstanden erlernten

Es ergab sich, dass die Vpp bei der Arbeit drei prinzipielle Methoden gebrauchten, —die sprachliche, die motorische, und die visuelle Mehr als die halfte der ganzen Gruppe gebrauchten sprachliche Verfahren irgend einer Art, nur Wenige losten die Aufgabe mittels visueller Vorstellungsbilder ("visual images") Die sprachliche ("verbal") Methode erwies sich als bei Weitem die beste Angriffsmethode Das zeigten alle drei Abschatzungsweisen, Zahl der Versuche, Zahl der Fehler, und Zeitgebrauch. Je schwieriger die Aufgabe wurde desto klarer zeigten sich die Unterschiede zwischen den verschiedenen Methoden in Bezug auf deren Wirksamkeit Hartnackige Fehler zeigten sich mehr bei der motorischen Angriffsweise, welche im Wesentlichen eine unbewusste ("unconscious") Lernmethode war, wahrend diejenen, die sprachliche Weisungen gebrauchten ihre Fehler rasch korrigieren konnten

Die Korrelationen zwischen Leistungen an dem Labyrinth und Intelligenz waren von bloss mittelmassiger ("fair") Hohe, im Wesentlichen weil der Gebrauch von verschiedenen Lernverfahren eine Art Doppelmodalität ("bimodality") erzeugte Der Übergang zu einem ahnlichen Labyrinth ermoglichte ein Ersparniss von etwa 2/3 der zum Erlernen des ersten Labyrinthes nötige Zeit, wahrend wenn das zweite Labyrinth ziemlich verschieden war nur etwa 1/4 der ursprunglichen Zeit erspart werden konnte Die Vpp, die ursprunglich mit verbalem Verfahren lernten hatten eine Woche spater viel mehr behalten wie diejene, die eine kinesthetische oder eine motorische Angriffsweise gebrauchten, obwohl die Ersten in der ersten Lernperiode weniger Übung gehabt hatten

Es scheint dem Verfasser als sicher, dass Lernmethoden nicht festgesetzt und nicht bei jedem Individuum einzigartig sind, und er empfehlt deshalb an, dass Lerner auch in Bezug auf die innere oder subjektive Angriffsweise einer Aufgabe gegenuber, und nicht nur uber die mehr objektiven Zuge des Problems Belehrung erhalten.

HUSBAND

SHORT ARTICLES AND NOTES

NOTE ON THE ERUPTION OF THE PERMANENT TEETH IN A GROUP OF SUBNORMAL CHILDREN, INCLUDING AN OBSERVATION ON THE FREQUENCY OF CONGENITALLY MISSING LATERALS

JOSEPH T. COHEN AND JOHN E ANDERSON

Upon the completion of a survey of the relation of the eruption of the permanent teeth to chronological age in a group of Minneapolis school children, it seemed worth while to obtain comparable data on a group of subnormal children by the application of the same method Collaboration with the Minnesota State School for Feeble Minded at Faribault was secured

A review of the literature shows that, while there is some difference of opinion among investigators, on the whole, most of the workers in this field, according to Perkins, "are agreed that children who deviate from the normal in mental development, do, generally speaking, show a deviation in physiological maturity"

Perkins (9), in a study of 555 cases, concludes that chronological age is a greater factor in dentition than mental age, that mental age shows a positive relationship to dentition, that when the intelligence quotient is low retardation in the eruption of the permanent teeth may be expected, and that extreme cases of delayed dentition suggest retardation in mental development

In the Woodrow and Lowell (7) study of 200 children, seven years six months of age, a low positive correlation between dentition and intelligence scores on the Kuhlmann-Binet scale was found But, on examining 120 girls under 13 years of age, Abernathy (1) found a high positive correlation between dentition and Stanford-Binet score, which became a low negative correlation when chronological age was held constant Using erupted permanent teeth to represent physiological maturity, DeBusk (5), in a study

of 200 children, found a correlation with intelligence level. Bean (2) found that, at each age from seven to fourteen years, children below their proper grade in school had 0.9 teeth less than the average, and that children above their proper age in school had 0.8 teeth more than the average child of their age.

On the basis of a study of 4000 English children, Levy (6) recommends the use of the eruption of permanent teeth for ascertaining the chronological age of children. At that time, due to the absence of birth registration, precise data on chronological age was rarely available. After the determination of chronological age by anatomical evidence was no longer a problem, the use of erupted teeth as a measure of physical development or physiological age was frequently suggested. Mumford (8) states that the dates of eruption of the cuspids, bicuspids, and second molars are important in estimating the physical age of a child. According to Spokes (10), the eruption of the permanent teeth is of value in indicating age but is not perfectly reliable. Cattell (3) refers to the eruption of the teeth as a physiological standard for development.

In the present study, the physically well children (218 in all) at the State School for the Feeble Minded (see Table 3 for distribution of ages) between the ages of five and fifteen years were examined.

The procedure followed involved an examination of the mouths of the children, with a record on a prepared form of the teeth present. In presenting the results no differentiation with reference to sex is made because the proportion of the sexes in the institution did not differ markedly from that in the group of normal children with whom comparison is made.

The number of permanent teeth present at the various ages for both the normal and subnormal group is presented in Table 2.

The subnormal children at all ages have fewer teeth than the normal children, the number varying somewhat from age to age. The mean dif-

TABLE 1

DISTRIBUTION OF MENTAL AGES OF SUBNORMAL CHILDREN

Mental age	Number of children examined	
	Boys	Girls
Below 3.0 years	35	31
3.0 to 4.0 years	19	13
4.0 to 5.0 years	17	10
5.0 to 6.0 years	10	14
6.0 to 7.0 years	14	13
7.0 to 8.0 years	8	10
8.0 to 9.0 years	11	8
9.0 to 10.0	3	2
	117	101

TABLE 2

AVERAGE NUMBER OF ERUPTED TEETH AT A GIVEN AGE
(Normal and subnormal children)

Age	School children (normal group) 2848 cases		Faribault children (subnormal group) 218 cases		
	No cases	Av no erupted	No cases	Av no erupted	Differences
5.0 to 6.0	98	1.6	2	1.0	0.6
6.0 to 7.0	168	5.2	5	4.6	0.6
7.0 to 8.0	334	8.8	22	7.1	1.7
8.0 to 9.0	354	12.1	20	11.7	0.4
9.0 to 10.0	437	14.1	17	13.1	1.0
10.0 to 11.0	484	17.6	37	16.0	1.6
11.0 to 12.0	467	21.3	23	20.3	1.0
12.0 to 13.0	268	24.9	36	24.6	0.3
13.0 to 14.0	137	26.4	31	25.3	1.1
14.0 to 15.0	101	27.4	25	26.7	0.7

ference, taking all the children into consideration, is 0.9 teeth in favor of the normal children. This figure agrees strikingly with that found by Bean (2).

The data are presented as ogive curves in Figure 1. The continuous heavy lines are the curves for the eruption of permanent teeth in a group of normal children as presented in a previous article by Cohen (4). The continuous light lines present the curves of the eruption of the permanent teeth in the subnormal children under consideration. There is a slight difference between the two groups. In general, each of the teeth of the normal children erupts somewhat earlier than do the teeth of the subnormal children. The difference is most marked in the posterior teeth and least marked in the anterior teeth.

In the course of the observations upon subnormal children it was noticed that congenital laterals were missing in sufficient frequency to justify a special study and comparison with normal children. To eliminate all possible sources of error arising from lack of development, in making this comparison no children below the age of ten years were included in either the feebleminded or the normal group, due to the fact that average age of eruption of the laterals in normal children according to the previous study is seven and seven-tenths years, with a semi-interquartile range of six-tenths of a year. Every one of the children in the study was sufficiently advanced chronologically for the permanent lateral to be present.

It was found that of the 1466 normal children who were examined 37, or 2.5%, had missing upper laterals, while of the 151 subnormal children 16, or 10.6%, had missing upper laterals. Four, or .27%, of the normal children had missing lower laterals as compared with 5, or 3.2%, of the

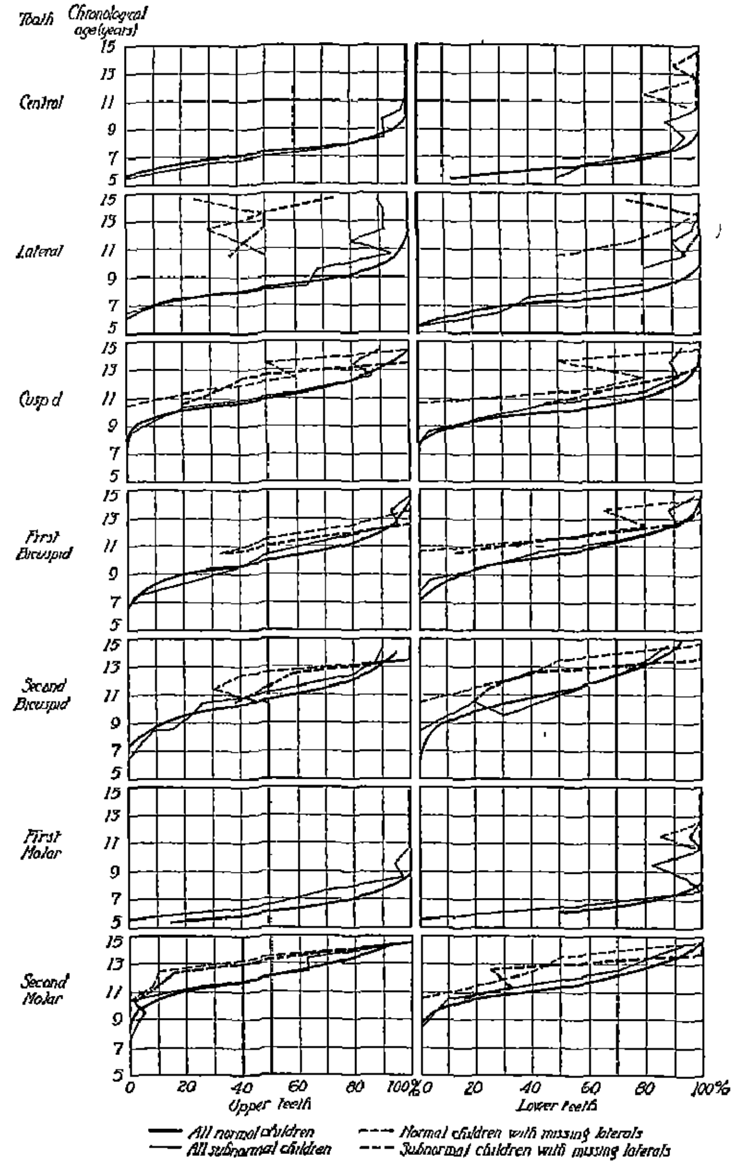
Tooth
Chronological age (years)
Central
Lateral
Cuspid
First Bicuspid
Second Bicuspid
First Molar
Second Molar
15
13
11
9
7
5
0 20 40 60 80 100%
Upper teeth
Lower teeth
All normal children
All subnormal children
Normal children with missing laterals
Subnormal children with missing laterals

FIGURE 1

subnormal children. Of the normal children 40, or 2.7%, had either upper or lower laterals missing, while in the subnormal children 20, or 13.2%, had either upper or lower laterals missing

Curves representing the eruption of the permanent teeth of feebleminded children with congenitally missing laterals and of normal children with congenitally missing laterals are also found in Figure 1 The heavy dotted line in each curve represents the curve of eruption for the particular tooth in a group of normal children with congenitally missing laterals and the light dotted line represents the curve of eruption in a group of subnormal children with congenitally missing laterals

These figures show that in the group of subnormal children with congenitally missing laterals each of the permanent teeth erupts somewhat later than is the case among children of the normal group who have congenitally missing laterals Further, in both the normal and subnormal groups of children with congenitally missing laterals, permanent teeth definitely erupt later than they do in children without such missing laterals.

Conclusions

1 Defective children have fewer permanent teeth at any age than do normal children

2 Permanent laterals are more often congenitally missing in a group of defective children than in a group of normal children.

3. Among children with congenitally missing laterals regardless of whether they are normal or defective the remaining teeth erupt later than they do in either normal or defective children without missing laterals

4 Among children with congenitally missing laterals, both normal and defective, the remaining teeth erupt somewhat later in the defective than they do in the normal children.

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INFLUENCE OF ILLNESS DURING THE FIRST TWO YEARS ON INFANT DEVELOPMENT

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It is a matter of common belief that sick children are slower to develop than are well children. In fact, this is statistically demonstrable. But here we encounter a danger of false interpretation The methodologist will at once point out that, although sick children are slow to develop, this slowness may with equal right be charged against their constitutional weakness or attributed to some specific illness It is the analysis of these factors that will concern us.

This study deals with the age at which children, *according to their parents,* hold up their heads, sit up without back support, cut the first tooth, creep, walk alone, say words in response to seen objects, and put two or more words together into a phrase. This information was secured concerning 94% of the pupils of a Seattle grade school (912 cases) Some of the records were incomplete, but there was little, if any, selective sampling

The trustworthiness of parents' testimony concerning the age at which their children develop the traits in question is none too great A constant error would, however, have no effect upon our conclusions Variable errors tend toward compensation and probably have little effect upon mean scores. The greatest source of selective error in this study would be a possible rationalization on the part of parents of slow children by which they seek to excuse their children's backwardness. This might conduce to an exaggeration of the remembered illness But most of the illnesses reported here were distinctly of an all-or-none sort.

Eighty-one cases, whose histories were complete, gave a history of severe illness during the first twenty-four months of life. The others denied such a history By severe illness is meant any of the five "children's diseases," pneumonia, diphtheria, any dangerous gastro-intestinal malady, rickets, a major operation, or a head operation

A comparison of the mean ages at which the sick group and the well, or control, group develop each of the seven traits that have been mentioned would be of but little interest This is because among the sick group some of the children had developed any particular trait before illness and some

after illness. The mean age of developing the trait might be increased only by those who had previously been ill

Again, if we calculate separately the mean age of developing a certain trait by those of the "sick" group who acquired the trait *before* their illness came upon them, and compare it with the mean for those who developed the same trait *after* their illness, we have results that are wholly misleading One reason that those who develop the trait before illness do so earlier than do those who develop it after illness is that the two groups are selected The naturally early-developers will have acquired more traits before sickness overtakes them than will the late-developers Therefore, when classified with reference to the acquirement of any trait, there will be a preponderance of early-developers among those acquiring the trait before illness and a corresponding preponderance of late-developers among those acquiring the trait after illness The direct effect of sickness in retarding development, as well as the effect, if any, of precocity or innate slowness in rendering the individual liable to disease, is not indicated by such measurements if they are carried no further

The percentage of children that acquire any trait after illness has overtaken them depends upon the age at which that trait is developed For a trait developed early the percentage will be relatively small For a trait developed late it will be relatively large It would follow, then, that the relative difference between the developmental age means of the sick group and of the control group would increase from trait to trait directly with the lateness of trait development, provided that illness causes the retarda-

TABLE 1

Trait		Mean age in months	$S\ D$	N	(x) Percent developing trait after illness	(y) $\frac{M_s - M_c}{M_s}$
Head up	control	2 400	1,31	513	25	.024
	sick	2 460	1 43	81		
Sitting up	control	5 341	1 49	619	49	076
	sick	5 778	1 81	81		
First tooth	control	6 965	2 48	742	56	066
	sick	7 454	2 86	81		
Creeping	control	8 440	1,75	583	71	099
	sick	9 372	2 26	81		
Words	control	10 261	3 90	602	74	078
	sick	11 126	3 85	81		
Walking	control	12 772	2 23	831	91	113
	sick	14 403	3,82	81		
Phrases	control	14 487	4 39	503	97	119
	sick	16 450	4,21	81		

tion In order to make comparison possible, the corresponding means of the sick group and of the control group are expressed as ratios. Also the percentage is given of the sick group that developed the trait after illness (Table 1)

The influence of illness will be shown as the quotients in column y vary with the percentages in column x. *The correspondence is high (Figure 1)* We may say, then, that there is a decided relationship between illness and retardation of development The truth of this does not have any bearing upon the presence or absence of other factors It does not eliminate, for example, the possibility that a third factor, such as some constitutional weakness, is responsible for both illness and retardation The answer to this doubt lies, however, within our data

If constitutional weakness alone had been the cause of retardation the correlation of x and y would have been 0, all the ratios in the y column being then presumably the same There might, of course, be a perfect correspondence between illness and retardation and a perfect correspondence as well between constitutional weakness and retardation But if constitutional weakness causes retardation, and is more frequently present in the sick group that in the well group, x will equal $ay+b$, where b is a constant representing the effect of constitutional weakness (Figure 1). This, however, is hardly the case according to what seems to be the line of best fit If there is such a thing as constitutional weakness that renders

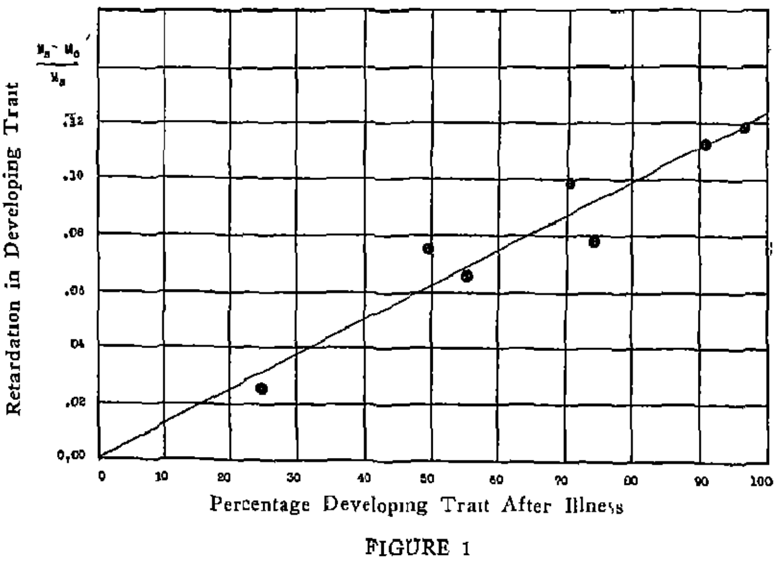

FIGURE 1

babies liable to disease its association with backwardness of development is not indicated by these results.

Any conclusion drawn from these data will be no more reliable than the data themselves The study should be repeated, using direct observation of babies and contemporary records.

By inspection of Figure 1, we would conclude that severe illness preceding the development of any trait reduces the apparent rate of development of that trait to about 88% of what it would otherwise have been. Or, stated differently, the most probable amount by which the age of developing a trait will be increased by severe illness is 14%

THE HAMPTON COURT MAZE

THURMAN C SCOTT

Professor E G. Wever of Princeton University called my attention to the fact that the diagram of the Hampton Court maze which is usually used is not the correct diagram of the Hampton Court Garden Maze I have been unable to find in psychological literature a true or correct diagram of this Hampton Court Garden Maze Several articles and textbooks contain diagrams of this maze, but they are all of the modified rectangular type and offer very little suggestion as to what the original pattern was like Small (2) has the following to say in regard to the pattern which he used "The Hampton Court Maze served as a model for the apparatus The diagram given in the Encyclopedia Britannica was corrected to a rectangular form, as being easier of construction" More recent authors simply refer to the pattern as the modified Hampton Court maze and some

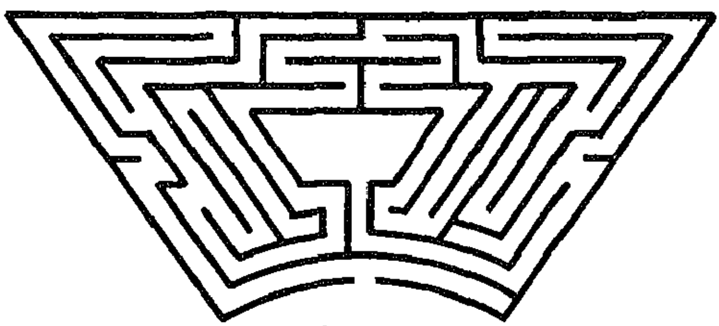

FIGURE 1
PATTERN OF HAMPTON COURT MAZE

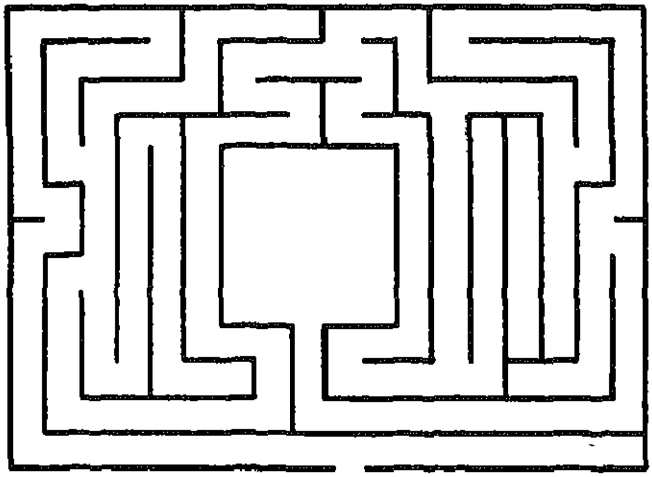

FIGURE 2
MODIFIED PATTERN OF HAMPTON COURT MAZE

of the most recent have omitted the word modified In fact, the rectangular form of this maze is possibly accepted by many people as the original form Since the Hampton Court maze can justly be called the "grandfather" of all mazes which are in use today, it seems that it might be worth while to call attention to the pattern as it existed in 1900 and still exists today in the Hampton Court Garden. This pattern, copied from the Encyclopedia Britannica, is given in Figure 1 In Figure 2 is found the modified rectangular pattern which is usually given in psychological literature

The following statement follows immediately the above quotation from Small: "The character of the problem was not affected" This statement may be true for rats, but there is some doubt as to whether it would be true for humans The author has obtained some evidence (1) indicating that the human subject finds oblique and acute angles more difficult than right angles. That is, the kinaesthetic sense of the human subject is not sufficiently developed for him to discriminate quite so keenly In learning a maze the human subject will sometimes make an oblique turn without knowing that he has changed his direction, and in making an acute turn will sometimes think that he is doubling back on the path which he has already traversed It seems possible, then, that such a change to a rectangular form might affect the performance of human subjects.

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AN OBJECTIVE AID IN THE STANDARDIZATION OF VERBAL DIRECTIONS

HAROLD M WILLIAMS[1]

The standardization of the verbal content of the instructions in testing young children has long been practiced. That significant changes in the meaning of a given verbal content may be introduced, however, by suitable variations in the rhythmic and inflectional patterns, and by changes in stress and voice quality is a matter of common experience Whether the meaning content of "This is a nice day" will be sincere or ironic depends almost entirely on analyzable factors in the manner of saying the words It is possible that with young children and animals these expressive aspects of speech may assume a position of crucial importance in meaning It is the purpose of this note to call attention to the possibilities of the phonophotographic techniques as aids in the objective measurement of some of these factors, particularly with regard to their usefulness as objective criteria in definite experimentation on the problem of the conveyance of meaning at the early ages

By the use of phonophotographic devices it is now possible to describe with accuracy the pitch and time factors in speech Emphasis in terms of loudness cannot be as satisfactorily measured at present, but it may be contended with some validity that changes in time and pitch are in themselves important aspects of emphasis, and that inflectional changes in pitch in speech are related in some degree to changes in intensity No simple device for the objective description of timbre changes is as yet available

In a recent study of the influence of external factors on motivation (2), praise and reproof were used as incentives The verbal content of each incentive was kept constant, but a question arose as to the tester's ability to routinize the expressive aspects of the sentences. Photographic studies were made, therefore, of the time and inflectional patterns of the praise incentive by the use of Metfessel's strobophotograph (3) for the purpose of measuring the consistency with which these patterns were repeated The results are shown graphically in Figure 1 In this figure three trials are shown, equivalent parts being grouped together to facilitate comparison

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[1]The experimental work was done while the writer was a National Research Council Fellow in Child Development at the Iowa Child Welfare Research Station, State University of Iowa, Iowa City, Iowa

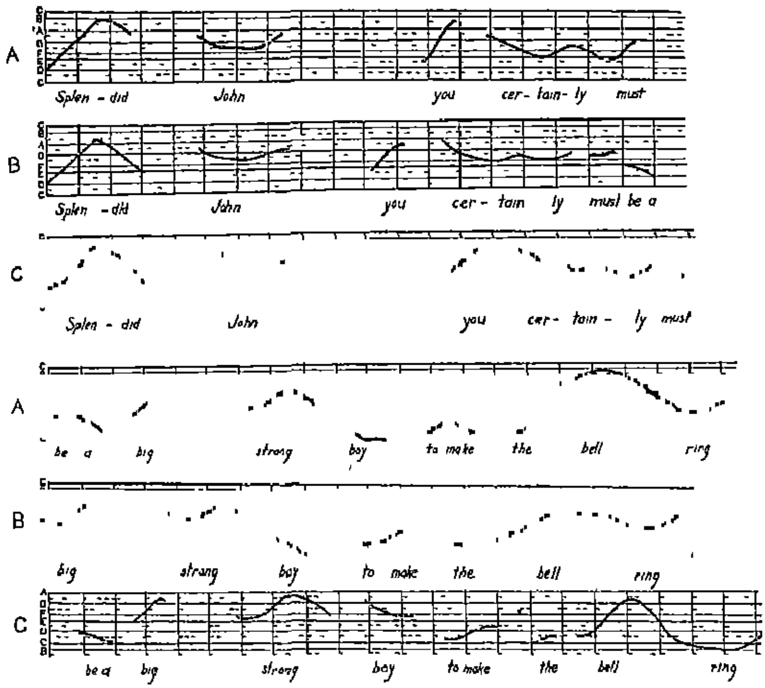

FIGURE 1

PHONOPHOTOGRAPHIC RECORD OF THREE REPETITIONS OF THE PRAISE INCENTIVE

Graph A is a record of the first trial, Graphs B and C show two attempts, one immediately following the other, made two weeks later Horizontal divisions on the graph represent one-tenth-second intervals Each vertical division represents one-half tone of the tempered scale

These records were made after the directions had been given a great many times in actual experimentation and show that the tester had been able to mechanize the pitch and time characteristics of the directions to a remarkable degree The words "splendid" and "John" are almost identical in time, pitch range, and inflectional form in the three trials The important phrase, "big, strong, boy," is also quite consistently given The largest difference is in the extent of the pitch inflection on "bell ring"

These findings suggested the possibility of measuring in the same way these characteristics in the speech of different people giving standardized directions Two situations were selected from the Stanford-Binet test (5), the number dictation series "9, 7, 2, 8, 4, 7, 5," and the absurdities test, "There was a railroad accident yesterday, but it was not very serious Only

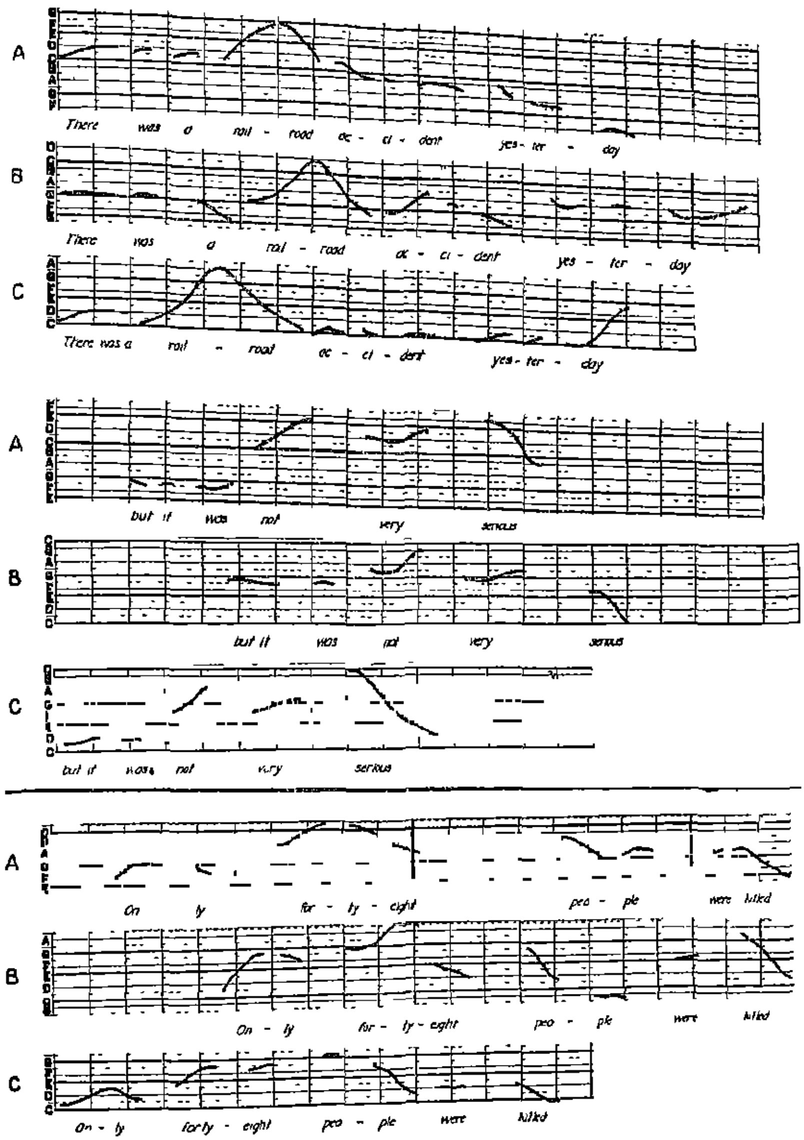

FIGURE 2

PHONOPHOTOGRAPHIC RECORDS OF THE ABSURDITIES TEST FROM THE STANFORD-BINET SCALE AS GIVEN BY THREE INDIVIDUALS

forty-eight people were killed" The records in Figure 2 are for the absurdities test, as spoken by three experienced Binet testers on the staff of the Iowa Child Welfare Research Station The material is arranged by phrases in order to facilitate direct comparisons

Noticeable differences in the rate of speech are to be found in the three records In the first phrase all three of the subjects emphasized the word "railroad," as is indicated by the large circumflex pitch intonation on this word One, C, has a rising inflection at the end of the phrase "Not" is emphasized in the second phrase by all three C again emphasizes "serious" with a very large falling inflection, starting at a higher point than any other word in the series In the last sentence "forty-eight" is emphasized by two, C again deviating by giving "people" considerable emphasis B seems to have emphasized "killed" more than the others The directions in the *Measurement of Intelligence* for this test are to read the sentence "rather slowly and in a matter-of-fact voice" The rather definite monotony of these graphs shows that the individuals concerned had striven for "matter-of-factness" in the dictation

In the number dictation, differences as high as 16% were found in the mean period between numbers, although the interval of one second was quite closely approximated. No particular evidences of rhythmic grouping were found. The chief point of difference to be found was that some of the testers spoke the final number with a large falling cadence, while others did not. The dropping of the voice at the end is undoubtedly in violence of the directions which state that the numbers are to be pronounced "with perfectly uniform emphasis"

The influence of expressive factors on meaning in verbal directions in a given situation can be determined only through experimentation It is known that grouping numbers in a temporal sequence makes the memory span for digits greater (4) The dropping of the voice at the end also probably makes the series easier Baldwin and Wellman (1) report that changes in the emphasis of a single word, "exact," made a large difference in the time score on the Wallin peg board with some five- and six-year-old children Such experimental evidence suggests, therefore, that some of these factors have a significant effect on test scores As convenient devices for the measurement of intensity and quality become available, it will be possible to measure with considerable exactness the influence of expressive factors in the conveyance of meaning in verbal directions. Where such factors appear of consequence in conditioning the responses obtained, these objective techniques may well be employed to check in advance the skill of the experimenter.

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BOOKS

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A R LURIA
GODFREY THOMSON
C J. WARDEN

THOMAS, W I, & THOMAS, D S *The Child in America* New York· Knopf, 1928 Pp. xiv+575

THOMAS, D. S *Some New Techniques for Studying Social Behavior* New York Bur Publs., Teach Coll, 1929 Pp viii+203

HEALY, W, BRONNER, A. F, BAYLOR, E M H, & MURPHY, J P *Reconstructing Behavior in Youth* New York. Knopf, 1929 Pp vii+325

CALVERTON, V F., & SCHMALHAUSEN, S. D [Editors] *The New Generation.* New York: Macaulay, 1930 Pp. 717

The first volume of this group represents a worthy attempt to bring before the student of social psychology the special problems of the child and to indicate the manner in which these problems are being dealt with in America The first section of the book sets forth the various types of juvenile maladjustment met with by the parent, teacher, and social worker Instead of the usual bare classification of specific problems, an attempt has been made to make each concrete by a guarded use of the case method The second section comprises a survey of the more common practical programs that have been tried out in different communities in the attempt to solve the problem of juvenile delinquency Child guidance clinics, community organizations, parent education, and character education programs are each given separate treatment in a special chapter The limitations of such practical programs are clearly pointed out and illustrated by concrete examples The final section of the book deals with the contributions of the following types of research programs psychometric, psychiatric, physiological-morphological, and sociological In the discussion of these various methods of approach, the authors show a broad grasp of the subject, and a sanely critical attitude.

The second volume is a collection of essays by numerous writers on methods of studying in an objective manner the social behavior of the child In general, the methods suggested were developed and tried out in connection with the work of the Child Development Institute of Teachers College, Columbia University

The third volume of the group is one of a series dealing with the work of the Judge Baker Foundation The present number is concerned with the problem of the placement of maladjusted children in foster families The first section of the book presents a classification of the types of maladjustment met with in work of this sort The principles underlying foster home care are also discussed in a special chapter. The second section of the book deals with the methods and problems of child placement, with emphasis upon the psychological aspects of the matter The final section comprises the results of an experiment in the placement of over 500 problem children. The relation of sex differences, illegitimacy, nationality, type of maladjustment, etc, to success in placement are discussed in the light of the actual results reported. This survey should be of considerable value to the worker interested in this special phase of social reconstruction.

The New Generation is a collection of writings on numerous topics relating in one way or another to the problem of the child and the home The value of the collection is decreased by the fact that certain chapters are by duly qualified specialists while others are by journalists and others of no scientific reputation The book is evidently intended for the layman, who can hardly be expected to know how to pick and choose in such a case The papers are grouped under five general headings, but the lack of unity within each section makes this seem quite unnecessary. The first section on the parent-child relationship includes topics as widely unrelated as savage education and reverence. The third section on "the family romance" is largely a jumble of psychoanalysis, with a special chapter by T. Swann Harding on "What Price Parenthood?" The final section ranges in scope from "the flapper" to "the decline of Mother Goose."

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Furfey, P H *The Growing Boy* New York: Macmillan, 1930 Pp. viii+192

Hollingworth, L S *The Psychology of the Adolescent* New York: Appleton, 1928. Pp. xiii+259

Brooks, F D *The Psychology of Adolescence.* Boston. Houghton Mifflin, 1929. Pp xxiii+652

The little volume by Furfey is merely a few case studies, of boys at different ages, brought together It does not appear to be written solely for the parent, although the presentation is extremely elementary It is not easy to see the value of so slight a treatment of so weighty a topic—certainly it falls entirely outside the textbook class

The volume by Hollingworth comprises a sympathetic treatment of the period of adolescence in the boy and girl. The author is to be commended

for omitting entirely the material on this topic as represented by the G Stanley Hall tradition The physiological basis of adolescence is passed over rather lightly, the main emphasis being upon the more strictly psychological aspects of the problem. The author stresses the fact that the coming of adolescence is not a sudden event but a gradual process Such fundamental problems as weaning from the home environment, the development of the capacity for self-support, the selection of a mate, and the achievement of an independent personality are dealt with in a clear and consistent manner Lists of suggestive questions and bibliographical material for the several chapters are available in appendices. This volume will doubtless be widely used as a textbook

The volume by Brooks differs from that of Hollingworth in several important respects. In the first place, it is much broader in scope The facts relating to the physical growth of the adolescent are detailed at length in a series of chapters, and the correlation between physical and mental growth emphasized throughout. In the second place, numerous facts relating to adolescence have been gleaned from the exeprimental literature and presented in tabular or graphic form. Finally, considerable attention has been given to disturbances of the adolescent personality. This volume will appeal to those who desire a textbook more comprehensive in these respects than that of Hollingworth.

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PRATT, K C, NELSON, A. K., & SUN, K H *The Behavior of the Newborn Infant* Columbus Ohio State Univ. Press, 1930 Pp. xiii+237

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BÜHLER, C. *Kindheit und Jugend* Leipzig· S. Hirzel, 1930 Pp xx+308.

BÜHLER, K *The Mental Development of the Child.* New York Harcourt, Brace, 1930. Pp. xi+170

CURTI, M W *Child Psychology.* New York Longmans, Green, 1930 Pp ix+527

PIAGET, J *The Child's Conception of Physical Causality* New York· Harcourt, Brace, 1930. Pp. viii+309.

The first book of this group represents the results of a long and careful investigation of the newborn infant conducted at the Ohio State University. It is the most thoroughgoing and systematic study of the infant that has appeared to date The sensory fields of light, sound, taste, smell, and temperature were covered, and special tests conducted on the sucking response of the infant and the response elicited by holding the nose. The volume contains brief reviews of the literature on the several topics, and a

selected bibliography It should prove to be of great value to all those interested in the experimental approach to the psychology of the infant

The second book dealing with the first year of life includes many first-hand observations regarding this very interesting stage of child development. The main value of the book, however, so far as the English reader is concerned, lies in the fact that the special tests designed by the author are here rendered available in convenient form A chapter on the practical reliability of these tests, which have not been widely applied to American children as yet, is also included

The other volume by the same author appears to be a worthy attempt to apply the genetic method to childhood and adolescence. The author recognizes the following age levels, treating each in a single chapter: first year, two to four years, five to eight years, nine to thirteen years, and fourteen to nineteen years The treatment of the first two age levels is much more systematic and complete than that for the later levels. A bibliography of only 47 titles is included in spite of the immense literature existing relating to the psychology of childhood and youth

The volume by Karl Buhler is not a systematic treatment of mental development in the child, but rather seven lectures dealing with more or less unrelated aspects of child psychology In the first lecture, the author develops the three concepts of instinct, training, and intellect, and discusses certain general aspects of the field In the second lecture, these three concepts are applied to the first year of life The remaining lectures deal in order with the following topics: perception, imagination, drawing ability, thinking, and social behavior, as related to the growing child

The volume by Curti is intended, according to the author, to be a comprehensive survey of the psychology of the *normal child* However, the book falls far short of its purpose in this regard since the selection of topics treated is relatively narrow as is usual in textbooks on this subject. The introductory chapter deals briefly with questions of method Of the remaining thirteen chapters, three are devoted to the general problem of heredity and environment, three to learning in the child, three to language and reasoning, two to delinquency, one to play, the final chapter being on the growth of personality. In topical treatment of this sort it is difficult to preserve the developmental continuity, and apparently impossible to emphasize properly the successive stages of growth and development. Nevertheless the book compares favorably with other recent treatments in which the genetic method has been subordinated to the topical

This last volume of the group appears to be the concluding number of the series by Piaget dealing with various aspects of the world of the child He attempts to trace the development of the notion of cause and effect from its first appearance in the naive and irrational conception of the child to the scientific conception of the adult During the period from three to eleven years, this development proceeds along the following three lines

simultaneously (1) from realism to objectivity, (2) from realism to reciprocity, and (3) from realism to relativity He finds no less than seventeen types of causal relation in child thought, which he classifies as follows: (1) motivation, (2) finalism, (3) phenomenistic causality, (4) participation, (5) magical, (6) moral, (7) artificialist, (8) animistic, (9) dynamic, (10) reaction of surrounding medium, (11) mechanical, (12) causality by generation, (13) substantial identification, (14) that involved in such schemas as *condensation, and rarefaction, (15) atomistic composition, (16) spatial* explanation, and (17) logical deduction Types one to six are dominant *in the early stage of the child's mental development; types seven to nine* during the next stage, and types ten to seventeen in the final stage. What all this arm-chair verbal analysis, supported by the outworn method of pertinent illustration, actually means it is difficult to determine The chief value of the book would seem to lie in whatever one may be able to glean from the illustrative material without regard to the analysis The illustrative material itself is so highly selected as to be wholly inadequate to support general conclusions concerning the evolution of the child's reaction to the external world

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$7.00 per volume
Single numbers $2 00

QUARTERLY

September, 1931
Volume XXXIX, Number 3

Founded by G. Stanley Hall in 1891

THE PEDAGOGICAL SEMINARY AND JOURNAL OF GENETIC PSYCHOLOGY

Child Behavior, Animal Behavior, and Comparative Psychology

SEPTEMBER, 1931

Chaque article est suivi d'un résumé en français
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Worcester, Massachusetts

Entered as second-class matter August 3, 1897, at the post-office at Worcester, Mass., under *Act of March 3, 1879*

THE WHITE RAT AND THE DOUBLE ALTERNATION TEMPORAL MAZE*

From the Psychological Laboratories of Clark University

WALTER S. HUNTER AND JOSEPH W. NAGGE

INTRODUCTION

In the original investigation of the rat's ability to master the double alternation response in the temporal maze, Hunter (4, 5) secured negative results The rat readily mastered simple alternation in a single T-shaped discrimination box, and, with great difficulty, it could master simple alternation in the temporal maze. Under the conditions of that experiment, however, double alternation was never established either in the T-shaped box or in the temporal maze. In a later investigation (7) Hunter trained rats first on a double alternation tridimensional maze (of the elevated type) and then transferred them to an elevated temporal maze where an effort was made to secure the double alternation response. Four rats received from 109-180 trials on this temporal maze, but only 7 responses were made which involved any significant aspect of double alternation The one remaining rat, after mastery of the tridimensional maze, was tested alternately on the tridimensional and temporal mazes, receiving 15 trials on the latter problem Of these 15 trials, 2 were perfect and 2 were partially so in a significant manner (*llrl*, left, left, right, left) Although these positive results were few in number they offered the suggestion that a new method of training might bring forth results positive in character and numerous enough to indicate that they were not due to chance.

In the present paper we describe such experiments Working first under conditions where the double alternation response could be set up in the rat, we have gradually modified the conditions of work until the subjects were being tested on the double alternation temporal maze. The results show that some rats can master the double alternation temporal maze problem, although with great difficulty We have not found, however, that they could extend the series of responses from the 4 on which they were trained to 6

*Received in the Editorial Office, January 19, 1931

or 8. In other words, when rats who had learned to make the double alternation response *llrr* were given an opportunity to extend this response to *llrrllrr*, the double alternation did not extend beyond the first 4 units. After that the response was usually to the right, making a series *llrrrrrr*. Apparently what the rat had learned to do was to go twice to the left and thereafter to the right. This is a strikingly different behavior from that found by Gellermann (1, 2, 3) in monkeys and human subjects, where the ability to extend the series was clearly present. In rats the factor which controlled double alternation was only operative in the specific series on which the animals were trained. In monkeys and human subjects, however, the controlling factor was not so limited in its range of application

SUBJECTS, METHOD, AND APPARATUS

Nagge used 29 normal, untrained albino rats, ranging in age from 45-82 days, and 6 rats who were 113 days old. Hunter used 20 normal, untrained albino rats, 30-45 days old. (All ages are given as of the first of the training)

The apparatus is shown in Figure 1. It consisted essentially

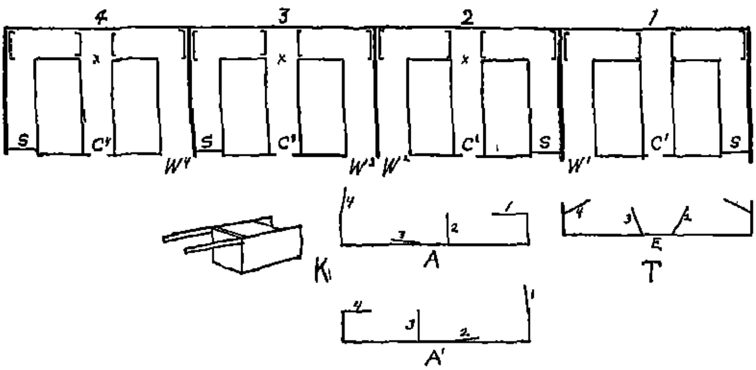

FIGURE 1

PLAN OF THE APPARATUS

The linear series of 4 boxes is arranged for double alternation in the order *llrr* C^1, C^2, C^3, C^4 are the entrances W^1-W^4 are the exits S designates the end-stops. The brackets show the location of the punishment grills T is the accessory unit for converting Box 1 into a temporal maze. E is its entrance. 1-4 designate swinging doors. K is the carrier used for transporting the rat from one box to another A and A' show the position of the doors of T in the normal series of *llrr* responses In A the doors are arranged for left responses; in A', for right responses

of four T-shaped boxes arranged in linear series. These boxes were arranged so that left responses were made in the first two and right responses were made in the last two boxes. *C* is the entrance door, and *S*, is the alley-stop *W* marks the exit The boxes were wired with punishment devices, the grills of which are indicated by the brackets in the figure The four boxes were constructed as nearly alike as possible The heavy lines at the two sides of each box in the figure represent partitions which extended about 18 inches above the tops of the boxes Four electric lights of equal intensity were suspended each above a central alley of a box. There was no other source of illumination in the room

The insert *K* in the figure represents the carrier-box in which the rats were transported from one part of the apparatus to another The insert *T* in the same figure represents the device used to convert Box 1 into a temporal maze This unit was placed directly in front of Box 1 and in contact with it. In addition to an entrance, *E*, there were four other doors, numbered *1, 2, 3, 4,* which served to direct the animal up the central alley (doors *2* and *3*) and to stop the animal when an error was made (doors *1* and *4*) Unless otherwise indicated later in the discussion the doors of the temporal maze occupied the positions indicated in Figure 1, insert A, during the four responses made in one trial The doors operated noiselessly, and they were never moved at a time when they might immediately condition a response at the point of selection, *x*

The rats were brought to the experimental room one at a time and were given one trial per day, each trial consisting of four responses in the order *llrr*. A trial was conducted as follows The rat was placed in the carrier, *K*, and brought to the entrance, C_1, of Box 1. When the rat reached the exit of this box, it was picked up (in Hunter's experiment), placed in the carrier and transported to the entrance of Box 2. This procedure was repeated for Boxes 3 and 4, after which the rat received its daily ration of food. Training was continued until the rat made 8 of 10 successive trials without error This means until on 8 of 10 successive days the rat had gone left in Boxes 1 and 2 and right in Boxes 3 and 4, thereby completing a double alternation response of four units, *llrr*

In Nagge's work the rat was not directly handled from the time it was first put in the carrier until the day's trial was over When the rat reached the exit, W_1, a small particle of food was placed in the carrier, *K*, which was held in front of the exit. The rat then

entered *K*, ate the food, and was transported to the entrance of the next box Food was secured in this manner at the close of the run in each box Hunter's method was adopted by him in order to eliminate the necessity for feeding during a trial and in order to decrease the interval of time between the responses making up a trial

Results

Table 1 shows the number of trials given each rat before the criterion of mastery was attained Of the 49 rats used, all but two mastered the response. These two rats were given 164 and 209 trials, respectively, but they failed to overcome the position habits into which they had fallen. The average number of trials for Nagge's group is greater than that for Hunter's group, but we do not attempt to explain the difference. The total range of trials is 24-162. This is a much better record than that made by Hunter's rats in the temporal maze as described in the 1929 paper (7) It also contrasts markedly with the negative results reported by Hunter in 1920 (5), where rats were trained in the T-shaped discrimination

TABLE 1
Number of Trials Required Prior to Mastery (3 Successive Trials Without Error) of the Double Alternation Response In Four Boxes

Hunter's rats		Nagge's rats			
Rat No.	Trials	Rat No	Trials	Rat No	Trials
1	47	1	26	17	48
2	41	2	29	18	38
3	34	3	not in 209	20	132
4	24	4	111	21	35
5	27	5	83	22	93
6	54	6	76	23	162
7	36	7	25	24	50
8	35	8	24	25	58
9	38	9	121	26	92
10	58	10	65	27	53
11	33	11	62	28	not in 164
12	25	13	84	29	28
13	26	14	78	30	50
14	36	15	127	31	110
15	82	16	74		
17	35				
18	46				
19	39				
20	46				
21	41				

box on double alternation. (It seems probable that the negative results in the earlier work were due to insufficient training of the animals, although individual differences and differences in the methods are not to be ignored as explanatory possibilities. In comparing the amount of training given in the two experiments, note is to be taken of the different senses in which the word trials is used in the two articles.)

Double alternation in the present apparatus of four boxes is not comparable to double alternation in the temporal maze. With the present apparatus, each of the four responses making up a trial is run in a separate box from which, or from the environment of which, differential stimuli sufficient to control the behavior might be secured. In the temporal maze, on the other hand, no differential stimuli are available either from the maze or the environment, inasmuch as the subject runs through the same portions of the maze and of the environment in successive units of the total response.

After the rats had mastered the double alternation response in the four boxes, our procedure was to introduce certain controls, partly in order to further the explanation of the behavior and partly as a system of intermediate training for the rat prior to being tested on the double alternation temporal maze where the results crucial for our experiment were to be secured. Before any of the following controls were introduced, each of the rats to be tested was trained beyond the criterion of mastery and required to meet the standard of 8 perfect trials in 10 successive ones.

We shall list first the controls used by Hunter and then those used by Nagge. One important difference between the two should be noted here. Hunter tested each rat from two to four times on each control. Prior to each control, the rat was required to make three perfect normal runs in succession. By this means the normal performance was kept at a high level of accuracy, and the control records threw light upon the mechanisms which functioned in the normal behavior. In Nagge's experiment, however, the controls were not so much controls as they were different stages in the training leading up to work on the temporal maze. In Nagge's study, when a rat had mastered *llrr* in the four boxes, and had then run 8 of 10 successive trials without error, it was put on Control 1 where it was trained until this control, or stage, was mastered to the extent of three perfect trials in four successive ones. With Control 1 mastered, Control 2 was introduced, and training was continued as

before. The work with the remaining controls proceeded in the same manner Occasionally, when a rat failed during the first trials with a given control, he was again tried on the previous control, after mastery of which the subsequent control was again used.

Hunter's Controls

Control 1 After the rat had reached W_1, W_2, or W_3 and had been placed in the carrier, K, the carrier was rotated 360° while transporting the rat to C_2, C_3, and C_1, respectively. An effort was made to make the transportation from point to point in the usual time and yet not to disturb the rat by upsetting its apparent equilibrium.

Control 2 The rats were given a test of their capacity to extend the series of responses, *llrr*, from 4 to 6 or 8, *llrrll* or *llrrllrr*. When the rat reached W_1 after the first four responses it was transported to C_1, and then from W_1 to C_2, etc.

Control 3 Here the boxes were used in the order 2, 1, 4, 3. In this case the rat was started at C_2, carried from W_2 to C_1, from W_1 to C_4, etc. The series of correct responses was still *llrr*, but the boxes (and hence whatever external stimuli were there operative) were utilized in a new order Furthermore, the environmental stimuli were presented in a novel order, inasmuch as the distance and direction of transportation from the various W's to the various C's was changed

Control 4. Only Boxes 1 and 3 were used. The first two responses, *ll*, were made in Box 1, and the last two responses, *rr*, were made in Box 3.

Control 5. Boxes 4, 3, 2, and 1 were used in that order The alley-stops, S's, were shifted before the control was begun so that the responses *llrr* could be run. In this control the two boxes, 1 and 2, in which the normal responses were *ll*, were now used for responses *rr*. Boxes 3 and 4 were used for the *ll* responses It is to be noted further that, while normally the rat progressed through the series of boxes (and hence through the experimental room) from right to left, in the present control he progressed from left to right

Control 6 In this control all of the responses were made in Box 1. All rats received 15 successive trials under these conditions. The problem is one of double alternation in a single box, and is the same problem set by Hunter (5) in his original study of double alternation in the rat

Control 7. After the completion of Control 6 the rats were blinded, and training was begun (24 hours later) in Box 1 modified into a temporal maze as described above in the section on apparatus

NAGGE'S CONTROLS

Control 1 After the rats had mastered *llrr* in the four boxes, they were tested in Boxes 1 and 3, *ll* in Box 1 and *rr* in Box 3

Control 2. Boxes 2 and 4 were now used, the rat being required to run *ll* in Box 2 and *rr* in Box 4

Control 3 Box 3, with the alley-stop shifted to the right side of the box, and Box 4 were used, the rat being required to run *ll* in Box 3 and *rr* in Box 4. In this case it is to be noted that Box 3 was normally used for *rr* responses

Control 4 Only Box 1 was used. The rat was trained until it could run *llrr* correctly on 8 of 10 successive trials.

Control 5. Box 1 was converted into a temporal maze, and the rats, *not blinded*, were given the *llrr* series with a morsel of food between each response as had been the procedure throughout Nagge's experiment

Table 2 summarizes the results secured with Hunter's controls. We are unable to offer here a normal error score, as Hunter did in his consideration of the sensory control of the maze (8), in terms of which to evaluate the significance of the percentages in the last column of the table So far as Table 2 is concerned, therefore, it is permissible to compare the various percentages one with another in an attempt to determine the relative effects of the various controls. However, it is not permissible to assume that the normal error score is zero, that is, that had no controls been introduced perfect records would have been secured Furthermore, in evaluating the results one must not lose sight of the possibility of a progressive change in the basis of the rat's behavior. To be sure, each control was preceded by a succession of three perfect normal trials, and yet the changing situations to which the rat was exposed in the various controls may well have resulted in changing the basis of its behavior. *In order to avoid this difficulty so far as possible, experimenters should give controls so that,* using the present experiment as an example, *some rats would take the controls in the order* 6, 5, 4, 3, 2, 1 *and others, in the order* 1, 2, 3, 4, 5, 6.

Table 2 shows that the first five controls disturbed the behavior of the rats in the following order, from least to worst. 4, 1, 3, 5, 2.

TABLE 2
HUNTER'S CONTROLS

	Control 1 *360° rotation between trials*		
20 rats, 48 trials	10 rats at least 1 trial with error 4 rats 2 or more trials with error 10 rats perfect	Rats perfect Nos 3, 4, 6, 7, 9, 11, 13, 14, 15, 20	Percentage of trials with error 35
	Control 2 *Extension of series*		
20 rats, 57 trials	2 rats each made 1 perfect extension 9 trials in 4 rats show some influence of double alternation in last 4 responses	Rats making perfect extensions Nos 4 and 12	Percentage of trials with error 96
	Control 3 *Influence of order of boxes*		
20 rats, 57 trials	19 rats at least 1 trial with error 11 rats 2 or more trials with error 1 rat perfect	Rat perfect No 4	Percentage of trials with error 61
	Control 4 *Reduction in number of boxes*		
20 rats, 56 trials	9 rats at least 1 trial with error 4 rats 2 or more trials with error 11 rats perfect	Rats perfect: Nos 5, 6, 7, 9, 12, 13, 14, 15, 17, 21	Percentage of trials with error: 25
	Control 5 *Reversal in direction and use of l boxes for r responses and vice versa*		
20 rats, 62 trials	All rats at least 1 trial with error 18 rats 2 or more trials with error		Percentage of trials with error 84
	Control 6 *llrr in Box 1*		
20 rats, 300 trials	14 rats made at least 3 perfect runs in succession	Rats perfect on first 3 trials Nos 3, 5, 6, 7, 10	
	Control 6a		

Rats 2, 5, 6, and 19 were tested in Box 1 for ability to extend the series *llrr* to *llrrll*. All responded *llrrr*

Control 1 was more disturbing than Control 4 when the percentages of the last column are considered However, the two are essentially alike in the number of rats affected as shown in the second column. In the absence of a normal error score, the most that we can say is that Controls 1 and 4 had little if any effect upon behavior. Controls 2 and 6*a* show that, under the conditions concerned, and *with but two isolated exceptions, no rat who was able to run the* double alternation of four responses could extend the series to one of six or eight responses

The results with Control 3 indicate the rôle of either or both of two factors. one, the serial order of the exteroceptive stimuli received in each box, and the other, the direction in which the rat was transported in the carrier between responses

The results of Control 5 indicate a severe disturbance of behavior under two conditions, (*a*) when left turns and right turns are required *in boxes where right and left turns respectively have normally* been made (thus changing the exteroceptive stimuli normally encountered prior to a given response), and *b* when the normal direction of transportation between responses is reversed

By the time the rats were tested on Control 6, five of them were able to run three perfect trials in succession in one box. (Since the subjects had not been tested sooner in one box, there is no way to determine how long they had had this capacity) Each rat received 15 successive trials on this control, and 14 of the 20 rats made at least three perfect trials in succession at some time during the control. Rat 7 made the first nine trials of the control without error. This was the best record secured Only two other rats made more than three perfect in succession, rat 10, who made four, and rat 19, who made five

We therefore seem justified in concluding that some rats can master double alternation in four boxes or in one box, but that this behavior is limited to the number of double alternations on which the subject has been trained. Where the behavior occurs in four boxes of the present type, the behavior is controlled to a certain but as yet undetermined extent by the exteroceptive stimuli from each box and by the stimuli involved in the normal mode of transportation from one box to the other.

If this experiment were to be repeated, we would make an important modification in the apparatus and method. The four boxes would be increased in number and would be mounted on a platform

which could be slid from right to left and vice versa. The rat would always be inserted in the apparatus at the same absolute position in space, and the apparatus would be moved back and forth as necessary in order to use the various boxes By this means environmental stimuli would be rendered more nearly non-differential and the different directions of transportation between boxes would be eliminated

Before considering the results secured when Box 1 was converted into a temporal maze, it will be necessary to examine the results secured with Nagge's controls It was pointed out above that Nagge's controls were in reality stages in the training through which the rats were brought to the tests first in Box 1 and then in this box converted into a temporal maze. We may, however, throw some light on the factors controlling behavior during the various stages by noting the ease or difficulty with which the rats mastered these stages.

Table 3 shows the results It is evident from this table that Controls 1, 2, and 3 are essentially on a par with respect to the number of rats entirely undisturbed by the shift from one condition of work to another. However, the evidence indicates that Control 3 was more disturbing than Controls 1 and 2 Of the 18 rats perfect on Control 1, 16 were also undisturbed by Control 2 Of the 18 rats perfect on Control 2, only 11 were undisturbed by Control 3. Ten rats were undisturbed by any one of these three controls Of these 10 rats, 7 were undisturbed by Control 5.

It would thus seem that seven rats had so thoroughly mastered the double alternation problem in four boxes that a reduction in the number of boxes from four to two and then to one did not disturb the response, although such a reduction entailed differences in exteroceptive stimulation from the boxes and differences in the direction of transportation (This statement is not meant to exclude the possibility that the *llrr* response became more thoroughly established as the work proceeded beyond four boxes or that the rats would necessarily have succeeded had they been tested on one box immediately after the mastery of four boxes) None of these rats, however, was able to extend the *llrr* series of responses in Box 1 to *llrrll* They had learned to run twice to the left and thereafter to the right so that the responses always occurred in the order *llrrrr*.

We come now to the consideration of the data secured with Box 1 converted into a temporal maze. We shall present Nagge's ex-

TABLE 3
NAGGE'S CONTROLS

Control 1
Reduction in number of boxes
Boxes 1 and 3
26 rats, 78 trials 18 rats undisturbed: Nos 1, 2, 4, 6, 7, 8, 9, 10, 11, 14, 15, 18, 20, 21, 24, 29, 30, 31

Control 2
Reduction in number of boxes
Boxes 2 and 4
25 rats, 75 trials 18 rats undisturbed Nos 1, 2, 4, 6, 7, 8, 9, 10, 11, 13, 14, 18, 20, 21, 24, 27, 29, 30

Control 3
Reduction in number of boxes and use of one L box for R response
Boxes 3 and 4
23 rats, 69 trials 17 rats undisturbed: Nos. 1, 4, 5, 6, 7, 9, 10, 11, 13, 16, 17, 18, 20, 25, 26, 30, 31

Control 4
Use in Box 1
23 rats, 69 trials 8 rats undisturbed Nos 1, 6, 10, 11, 16, 18, 20, 30
13 rats mastered the problem, 3 perfect trials in succession in 1-44 trials
2 rats failed to learn in the 12 and 23 trials given

Summary
6 rats undisturbed on Controls 1 and 2, but disturbed on Control 3
7 rats disturbed on Controls 1 and 2 or Controls 1 or 2, but not on Control 3
10 rats undisturbed on Controls 1, 2, and 3.
16 rats undisturbed on Controls 1 and 2.
11 rats undisturbed on Controls 2 and 3

periments first. His experiments were conducted with three successive methods: (*a*) The rats were fed a morsel of food between each response as had been the case in all of their previous training (*b*) This feeding was discontinued, and the rats were fed only at the close of the day's work (*c*) The rats were blinded, and Method 2 was continued

Of Nagge's 23 rats tested on Control 4, only 16 were tested on the temporal maze The remaining 7 animals had progressed so slowly in their training that no adequate amount of time was available for continuing them on the problem. *Method 1* Of the 16 rats, 15 mastered the problem, 3 perfect trials in succession, in from 1-44 trials One rat was still unable to respond correctly after 79 trials, 1 per day *Method 2*. 12 of the 16 rats used with Method 1

were tested with Method 2 Eight rats mastered the problem after from 0-51 trials The remaining 4 rats received an insufficient number of trials, not to exceed 38, to determine whether or not they might have mastered the problem eventually *Method 3.* The 8 rats who had mastered *llrr* under the conditions of Method 2 were blinded, and 24 hours later training was continued. Three rats were able to run 3 successive trials without error within the 30 trials which they received The remaining 5 rats received 7, 18, 20, 20, and 29 trials, respectively, but they did not master the problem.

It is, perhaps, not surprising that the shift from Method 1 to Method 2, with the consequent change in feeding technique, should have disturbed the animals. The disturbance occasioned by Method 3, where the only change was that the rats were blinded by removing the eyeballs, would indicate that vision had been playing a rôle in the previous behavior.

The data on Hunter's rats in the temporal maze remain to be considered. Of the 20 rats who received 15 trials in Control 6 (*llrr* in Box 1), 17 were blinded and, 24 hours later, training was resumed in Box 1 modified into a double alternation temporal maze. Table 4 makes possible a comparison of the performance during the last five trials with Control 6 and the first five trials with the temporal maze. It will be seen that, of the 20 rats tested, 15 made three perfect runs in succession at some time during this control. However only 9 rats made three correct trials in the last five, and only 3 rats were perfect in all of the last five trials. After being blinded, *no* rat made more than two perfect runs in the first five trials with the temporal maze. In the present case, the loss of the habit following blinding may have been due either to the loss of vision or to the necessary differences in procedure in Control 6 and the temporal maze

Table 5 gives the records of the 17 rats who were tested in the temporal maze The same total number of trials could not be given each animal because they completed the work on Control 6 at different times, whereas the experiment as a whole had to stop at the same time for all subjects Consequently, the subjects who had progressed most rapidly through the various controls received the most adequate testing in the temporal maze Eight of the 17 rats made at least three correct trials in succession once during their training, requiring a median of 26 trials and a range of 17-79 trials to reach this standard of mastery The median number of trials received by

TABLE 5

HUNTER'S RATS ON THE TEMPORAL MAZE

Rat	Total trials	Trials prior to 3 perfect runs in succession	Maximum no. perfect runs in succession	Total no *A* records	Total no *B* records
1	59	never	2	0	0
3	92	60	8	9	6
5	68	never	2	4	1
6	62	56	3	0	0
7	63	never	2	0	0
8	29	never	1	0	0
9	73	24	9	29	7
10	29	never	0	0	0
11	79	17	3	2	0
12	40	never	0	0	0
13	86	79	7	3	1
14	84	28	7	31	10
17	27	never	0	0	0
18	43	never	2	0	0
19	56	never	1	0	0
20	64	18	4	12	5
21	35	24	3	6	3

TABLE 4

PERFORMANCE IN CONTROL 6 AND IN THE FIRST FIVE TRIALS WITH THE TEMPORAL MAZE (HUNTER'S EXPERIMENT)

Rat	No trials perfect in last 5 trials of Control 6	No trials perfect in first 5 trials of temporal maze
*1	2	2
2	1	–
*3	2	0
*4	2	–
*5	5	1
6	2	1
*7	5	0
*8	3	0
*9	3	0
*10	3	2
*11	5	0
12	2	0
*13	2	1
*14	1	2
*15	0	–
17	3	1
18	2	0
*19	3	0
*20	3	0
*21	2	2

*Rats which made at least three correct trials in succession on Control 6.

the 9 rats who failed was 43, with a range of 29-68 trials It would thus appear not only that mastery of the double alternation response in one box, as in Control 6, is no indication that the temporal maze can be mastered, but that the temporal maze is a problem of great and unusual difficulty for the rat. This latter fact is evidenced in the detailed data which show that even the rats who master the problem are usually unable to perform it correctly for many successive trials These data are partially represented in Column 4 of Table 5 which gives the maximum number of successive perfect trials made by each rat.

Attention must now be called to the important data of Columns 5 and 6 of this table. The *A*-records of Column 5 refer to tests of the following character: The two side doors, 1 and 4 of Figure 1A, were both open when the rat entered the maze but the two central doors, 2 and 3, were in a position to force the rat into the central alley. As soon as the rat had entered the central alley, Doors 2 and 3 were opened *None of the doors of the maze was then moved in any way* during the rat's *llrr* responses. After the animal had run through the left side of the apparatus, for example, and had returned to the entrance, there was no door, 2, in position to turn the rat into the central alley The records in this column of the table show that rats Nos. 9 and 14 could perform the *llrr* response under these conditions with a very high degree of proficiency. Rats Nos. 3, 5, 20, and 21 were less efficient, but they were still able to make the response The significance of these records is derived from two considerations. (*a*) Since the doors were not operated after the animal had started its response, no cues could have been secured from the doors. (This was apparently true in the regular tests also inasmuch as the doors were operated only when necessary to block retracing and were never operated at a time when they might influence the choice of right or left turns.) (*b*) The animals making the records now under consideration did not even need the doors in order to turn into the central alley after completing a run around either the right or the left side of the apparatus. (It is to be recalled that all animals were blind.)

Column 6 of Table 5 records the total number of *B*-records By a *B*-record is meant a successful response made under the following conditions: All doors of the maze were opened *before* the rat was placed in the maze, and *no* door was ever operated while the rat was in the maze. Rats Nos. 3, 9, 14, 20, and 21 each made more than

one successful *llrr* trial under these conditions. Rat No. 14 in particular made an excellent record with 2 and 3 correct trials in succession and with a total of 10 correct trials of the *B*-type.

After mastery of the temporal maze to the extent of three perfect trials in succession as shown in Column 3 of Table 5, rats Nos. 3, 6, 9, 11, 14, and 20 were occasionally tested on an extension of the normal *llrr* series to the series *llrrll*. In no case were the subjects able to make this extension correctly. In every case the response was *llrrrr*, twice to the left and always thereafter to the right.

Conclusions

White rats have mastered the double alternation response when trained in four boxes arranged side by side. Some of the animals have also been able to perfect the response when the number of boxes is reduced to one, and a few blinded animals have mastered the problem when this one box was converted into a temporal maze. A few rats have been able to run the double alternation temporal maze without error when the doors of the maze were not operated during an entire trial.

Numerous tests were made to determine whether or not the rats could extend a series of four responses, *llrr*, to *llrrll* or *llrrllrr*. The results are fundamentally negative. Only two isolated cases of perfect extension of the series were found. Whatever factor, or factors, controlled the behavior, the efficiency of the control was limited to the series upon which the rats were trained.

Our experiments have thrown no new light upon the nature of the processes in the animal which make possible a perfect double alternation response in the temporal maze.

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LE RAT BLANC ET LE LABYRINTHE TEMPOREL À ALTERNATION DOUBLE

(Résumé)

Les auteurs continuent l'étude du contrôle sensoriel-nerval de l'action en series avec une enquête de la capacité du rat de resoudre le problème de l'alternation double Bien qu'on ait obtenu jusqu'ici seulement des resultats négatifs avec le rat, les auteurs ont obtenu des résultats positifs dans l'expérience actuelle par l'emploi d'une méthode nouvelle d'entraînment Quelques rats ont appris l'alternation double en quatre boîtes séparées, une boîtes pour chaque réponse On les a transférés ensuite avec succès à deux boîtes et enfin à seulement une boîte, en chaque cas l'alternation double étant apprise Quelques rats, quoiqu' aveugles, ont pu courir parfaitement le labyrinthe temporel à alternation double quand il n'a existé en apparence nulle possibilité de suggestions extérieures. Les auteurs ne présentent nulles analyses théoriques nouvells des facteurs qui contrôlent ce type de comportement Leurs résultats, cependant, indiquent que si l'on entraîne le rat sur une série de quatre réponses, en l'ordre gauche gauche droite droite, il ne peut étendre la série de réponses à un total de six ou huit, c'est-à-dire, de *ggdd* à *ggddgg* ou à *ggddggdd* Il semble que le facteur qui contrôle le comportement soit limité à la situation expérimentale où il a été établi Ceci n'est pas vrai au cas des sujets humains et des singes, comme l'indiquent clairement les expériences de Gellermann.

Hunter et Nagge

DIE WEISSE RATTE UND DAS LABYRINTH MIT DOPPELTER WECHSELFOLGE (DOUBLE ALTERNATION MAZE)

(Referat)

Die Verfasser setzen ihr Experiment der sensoriell-neurologischen Regelung der serienhaften Taetigkeit fort, indem sie die Faehigkeit der Ratte, der Aufgabe der doppelten Wechselfolge gerecht zu werden, untersuchen Obwohl bis jetzt mit Ratten nur negative Resultate erzielt worden sind, ist es den Verfassern mittels einer neuen Methode der Dressierung gelungen, in den gegenwaertigen Untersuchungen positive Resultate zu erzielen Einige Ratten haben die doppelte Wechselfolge in vier verschiedenen Kaesten durchgefuehrt, indem jeder Kasten eine andere Reaction in Anspruch nahm Es ist den Verfassern dann gelungen, die Ratten zuerst in zwei Kaesten und denn in einen einzigen Kasten zu uebertragen wobei sie in jedem Fall die doppelte Wechselfolge durchfuehrten Einigen Ratten war es trotz Erblindung moeglich, fehlerfrei durch das Labyrinth zu rennen, obgleich keine Moeglichkeit zu bestehen schien, sich nach Anweisungen von aussen zu orientieren Die Verfasser bieten keine neuen Analysen der Faktoren, die diese Form der Taetigkeit regeln Ihre Befunde weisen aber darauf hin, dass wenn die Ratte in einer Serie bestehend aus vier Reaktionen (responses) in der Anordnung links, links—rechts, rechts dressiert worden ist, es nicht moeglich ist, die Reaktionsserie auf sechs oder acht Reaktionen zu erstrecken, d h von l l r r auf l l r r l l oder l l r r l l r r Es scheint, dass das kontrollierende Element bei der Taetigkeit sich lediglich auf die experimentelle Situation beschraenkt, in der sie festgelegt worden ist Dies ist bei menschlichen Versuchspersonen und bei Affen nicht der Fall, wie aus Gellermann's Versuchen klar ersichtlich ist

HUNTER UND NAGGE

A STUDY OF CERTAIN INCENTIVES APPLIED UNDER SCHOOLROOM CONDITIONS*

From the Department of Psychology of Columbia University

C. J. WARDEN AND A. COHEN[1]

While numerous studies of motivation have been made in connection with work in the schoolroom, in few cases have tests been conducted under strictly schoolroom conditions. As a rule, one important element of school life has been ignored in that the tests were given by an outsider rather than by the regular teacher. The aim of the present study was to determine the influence of certain incentives commonly used by grade teachers when applied by the teacher in the ordinary course of the daily routine.

The group tested included 18 boys and 20 girls comprising a fourth-grade room of one of the public schools of Wallington, New Jersey, ranging from 9 to 13 years of age, the average age for both boys and girls being 10 years. The study was carried out during the school year of 1926-1927. The task consisted of drill work in addition, in which the Thorndike Addition Sheets, with 48 single columns per sheet, were employed. In order to secure different but equivalent sets of material to be used from time to time, the columns were cut into strips and glued by machinery on heavy paper of the same size as the original sheets in all possible arrangements. The drill was limited to five minutes and in every case immediately followed the morning exercises which were kept as constant as possible during the several weeks over which the test extended. The task and the general conditions under which it was performed were thus kept uniform throughout.

The special or incentive condition varied from day to day in accordance with the schedule indicated in Table 1. During the first week no incentives were offered. This procedure enabled the teacher to introduce the drills without any special connection with the factor of incentives. It also made it possible to secure a good index of

*Received in the Editorial Office October 30, 1930.

[1]This experiment was planned and carried out in cooperation, the junior author securing and tabulating the data, and the senior author being responsible for the report in its present form.

TABLE 1
SCHEDULE OF INCENTIVES

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1	No incentive	No incentive	No incentive	No incentive	No incentive
2	Story	No incentive	Story	No incentive	No incentive
3	No incentive	Game	No incentive	Game	No incentive
4	No incentive	No incentive	Story	No incentive	Game
5	Omitted	Omitted	Omitted	Omitted	Omitted
6	Omitted	Reproof	Omitted	Praise	Omitted
7	Omitted	Omitted	Easter Party	Omitted	Omitted
8	Omitted	Omitted	Omitted	Omitted	Omitted
9	Play Delayed	Play Delayed	Play Delayed	Play Delayed	Play Delayed

non-incentive performance and insured a thorough understanding of the requirements of the task. Emphasis throughout was placed upon accuracy rather than speed, although speed was somewhat encouraged Time was taken with a stop-watch On the first day the following instructions were given

> "I have here a page of single column additions I want you to do I am going to give you five minutes You will not be able to do them all Do as many as you can in the five minutes and do them as well as you can (at this point the papers were passed out). Keep your papers turned over on your desk so that you cannot see the problems All pencils down when I say '*stop*' *You will have five minutes* Ready, papers over, begin!"

The directions were shortened to the following on the remaining days of the first week.

> "You have more problems to do today like those you did yesterday Remember! Do as many as you can and do them as well as you can Ready, papers over, begin!"

On checking through the papers for the first week it was noted that the accuracy of the work was rather low It seemed wise, therefore, to alter the instructions for the regular series of tests by placing more emphasis upon accuracy. The instructions thereafter ran about as follows

> "You will have more problems in addition to do today. I want to see how many you can get *right* in five minutes Did I say you must do the whole page? [Class "No"] What did I say? [Class "Do as many as we can but get them right"] Yes, I want to see if you can get 100. If you do well today I

will read you a story [or whatever the incentive was at the time]."

The several incentives employed require little description. A continued story, which would naturally arouse most interest was always used. The game to be played was chosen by the children and, as it happened was always "Initial Tag." Reproof followed a week in which the task had been omitted and the children had good reason to suppose that their previous work had been given a thorough checking over. It was administered in the following language.

> "I have been looking over the addition drills you did last month. They were very poorly done. You seem to think the idea is to do as many as you can even if you get them all wrong. What good is a paper that has 26 done and only 2 right, or 45 done and only 1 right. There were some good scores, such as 26 done and 23 right. But most of you get too many wrong. Now, today I want to see how many you can get *right* in five minutes."

On Thursday of the same week, the children were praised as follows.

> "You did much better the other day on the additions. All of you improved a great deal. The work was fine. Today I want to see if you cannot do still better. Let's all try to get 100 today."

The seventh week came just before Easter, and the plan of using the incentive of an Easter party on Wednesday afternoon naturally suggested itself. After omitting the drills for one week, they were run again each day of the ninth week with the incentive of a half-hour of outdoor play to be given on Friday afternoon. The last series, therefore, involved the factor of delayed incentive. The reward was always given regardless of the actual record made by the group.

After the completion of the work, the children were given the National Intelligence Test and the Dearborn Non-Language test so that any possible relationship between the motivation factor and the IQ might be determined. The records were also at hand so that comparisons could be made between the motivated and non-motivated drill scores and the yearly grade in arithmetic and the general average for all school subjects.

Since it was desired to adhere strictly to schoolroom conditions, the plan was adopted of offering incentives only on certain days and at

irregular intervals Omission of the drills at the times indicated in Table 1 also tended to keep the conditions natural. In making comparisons between incentive and non-incentive scores the factor of unequal practice effect may enter to some extent. The preliminary week of practice was intended to overcome this defect in control by bringing the group to a high practice level before the special conditions were introduced. In spite of the fact that simple addition of this general sort belongs to the curriculum of this and earlier grades, the gains made during the preliminary week of practice were considerable The average gain in speed for the boys was from a score of 10 on the first day to a score of 15 on the last day, and the corresponding scores for the girls were 9 and 14 The gain in accuracy was about as great, the boys showing a gain of from 7 to 9 and the girls a gain of from 6 to 9. The number of items completed constituted the speed score, and the number of correct items the accuracy score.

The results obtained under the several conditions are shown in Table 2. The scores for the same incentive when applied on different days have been combined which tends to reduce any inequality of practice effect that may have been present For example, the scores for *story* as indicated in the table represent a combination of the scores made on Monday and Wednesday of the second week and on Wednesday of the third week. In like manner, the score for *game* involves tests spread over the third and fourth weeks It did not seem advisable to make use of praise and reproof but once, and an Easter party could be given but once, of course. The factor of delay was brought into the work of the ninth week in connection with the incentive of an hour of outdoor play to be given at the close of the week. The scores for the entire week were combined in computing the value of this rather commonly used incentive The non-incentive score represents a combination of 9 periods of work without incentive spread over the second, third, and fourth weeks

It is rather clear from the data of Table 2 that the incentives were not especially effective, at least insofar as the factor of speed is concerned When all incentive scores are combined and compared with all non-incentive scores, the slight difference found is seen to favor the non-incentive condition. This difference is entirely negligible in the case of the boys The incentives appear to be effective, however, in improving the accuracy score for both boys and girls alike This result agrees with the findings of others in studies of

TABLE 2

SPEED AND ACCURACY SCORES UNDER THE VARIOUS CONDITIONS

Conditions	Speed Boys	Speed Girls	Speed Comb	Accuracy Boys	Accuracy Girls	Accuracy Comb.	Percentage of accuracy Boys	Percentage of accuracy Girls	Percentage of accuracy Comb
Story	15 7±.50	15 8± 50	15 8± 36	9 6± 59	7 2± 53	8 2± 34	61	46	52
Game	18 6± 38	18 6± 60	18 6± 42	10.4± 63	8 4±.39	9 5± 37	56	45	51
Reproof	16 5± 70	14 7± 62	15 5± 49	11 2± 96	8 6± 69	9 8± 61	69	60	64
Praise	16 9± 77	15 4± 51	16 1± 48	11 0±1 13	10 4± 65	10.7± 67	65	67	66
Party	17 1± 79	13 8± 53	15 4± 52	10 6±1.05	8 7± 63	9.6± 61	62	63	62
Play	16 1± 69	12.4± 39	14 6± 46	10 9±1 02	8 5± 44	9 5± 53	68	68	68
Incentive comb	16 8± 32	15 0± 29	15 9± 23	10 5± .34	8 5± 24	9 4± 23	62	57	59
Non-incentive comb	17 0± 39	16 4± 51	16 7± 36	10 0± .37	7 9± 53	8 7± 31	59	48	52

motivation under the usual test conditions. The increase in accuracy under incentive conditions is more apparent in the percentage scores of Table 2. These scores were obtained by dividing each accuracy score by the corresponding speed score multiplied by 100 On the whole, the relative gain in accuracy was greater for the girls.

The value of the several incentives varies considerably not only within the same sex but also as between the sexes, as might be expected. Game stands out as being the most effective, insofar as speed is concerned, the accuracy score being average. Story is evidently the least effective, although not markedly so. When accuracy scores alone are considered, praise and reproof rank highest, although not very much above the average On the whole, the incentive of delayed play appeared to have much more appeal for the boys than for the girls, as indicated by the absolute scores. However, the relative accuracy score is the same for both boys and girls and is the highest obtained in the tests It is interesting to note that the daily scores showed a consistent rise throughout the week as the time allotted for play was approached

The correlations shown in Table 3 require little comment. The IQ represents a combination of the ratings secured on the National Intelligence Test and the Dearborn Non-Language Test The correlations between drill score and arithmetic grade for the year, and between drill score and the general school record for the year, are notably higher than those between drill score and IQ under all conditions In both instances the correlations are higher for non-incentive conditions in speed comparisons and for incentive conditions in accuracy comparisons. This suggests that the incentives were mainly effective in inducing accuracy, and in many cases at the expense of speed. Any further interpretation of the correlations does not seem possible.

Several points of a more or less general nature should perhaps be noted. In the first place, it was evident that specific motivation was

TABLE 3
COEFFICIENTS OF CORRELATION

Comparisons	Speed Incentive	Speed Non-incentive	Accuracy Incentive	Accuracy Non-incentive
Drill score—I Q (comb)	20± 06	.08± 04	.30± 01	31± 09
Drill score—Arith Gr	40± 09	42±.09	55±.07	47± 08
Drill score—School Av	34± 10	51± 08	45± 08	29± 10

not wholly excluded during tests on non-incentive days. The children did not remark about the omission of incentives on these days, and it is quite possible that the general set carried over to the work of these days. Self-competition was more or less common, since in many cases the children counted the number of columns they had completed and seemed disappointed if the number were less than their previous record This might have been prevented, but, after all, it is essentially a part of the usual incentive condition in actual schoolroom practice. In the second place, it is not at all impossible that the increase in accuracy under incentive conditions was due not so much to the incentive itself as to the emphasis upon accuracy in the directions repeated each time This may also be the proper explanation of other investigations in which increased accuracy rather than speed has been found, and often interpreted to be specifically due to the incentive employed. The conclusion seems to be warranted that these commonly used incentives are not as effective as might be supposed, at least insofar as the type of task investigated is concerned, when applied under schoolroom conditions. Had the task been of a different nature, or longer and more difficult, the results might also have been different. The present findings should also be restricted to the particular age and intelligence level tested.

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UNE ÉTUDE DE CERTAINS STIMULANTS APPLIQUÉS DANS LES CONDITIONS DE LA SALLE DE CLASSE

(Résumé)

C'est une étude de tels stimulants qu le conte, le jeu, le reproche, l'éloge, une fête à Pâques et une heure de recréation en plein air à la fin de la semaine, appliqués au cours ordinaire de la routine de la salle de classe La tâche se composait des "Thorndike Addition Sheets" auxquells on a dévoue cinq minutes après les exercices du matin Les élèves ont inclus 18 garçons et 20 filles, une salle de classe de quatrième année de l'école élementaire, chaque groupe ayant en moyenne dix ans Les stimulants ont semblé augmenter l'exactitude absolue et relative mais ont eu très peu d'effet ou nul effet sur le résultat de vitesse A tout prendre, le stimulant du jeu s'est montré le plus efficace et le conte l moins efficace, les moyennes des autres étant environ les mêmes Les corrélations ont été peu élevées entre le résultat du test, avec ou sans stimulant et le Q I. On a trouvé des corrélations plus élevées entre le résultat du test et les notes annuelles en calcul et les notes générales a l'ecole Celles-ci ont éte plus élevees pour les résultats de vitesse sans stimulant, et les résultats d'exactitude avec stimulant

WARDEN ET COHEN

EINE UNTERSUCHUNG GEWISSER ANSPORNUNGEN BEI DEN VERHALTNISSEN DES SCHULZIMMERS ANGEWENDET

(Referat)

Die Verfasser untersuchten Anspornungen ('incentives') wie Geschichten, Spiel, Vorwurf, Lob, Osterfest, und eine Spielstunde im Freien am Ende der Woche in ihrer Anwendung auf den gewohnlichen Verlauf der Schulzimmerroutine Die Aufgabe war die Addition von Ziffern auf den Thorndikeschen Additionsblattern ('Thorndike Addition Sheets'), denen 5 Minuten [jedes Schultages] nach der Morgenzeremonie ('morning exercises') zugeteilt wurden Die Schuler waren die 18 Knaben und 20 Madchen eines Zimmers fur vierte Klasse. Das Durchschnittsalter fur jede Gruppe war zehn Jahre Die Anspornungen schienen so wohl die absolute wie die relative Genauigkeit zu verstarken, hatten aber keinen Einfluss auf die Schnelligkeitsziffer Im grossen Ganzen zeigte sich die Spielanspornung als die wirkungsvollste und die Geschichte als die am wenigsten wirkungsvolle Die Durchschnittszahlen fur die Anderen waren ungefahr gleich. Die Korrelationen zwischen Arbeitsziffer ('drill score') und Intelligenzziffer ('intelligence quotient') waren mit oder ohne Anspornung niedrig. Hohere Korrelationen erwiesen sich zwischen der Arbeitsziffer und der Zensur im Rechen fur das Jahr, und zwischen Arbeitsziffer und Schulrang im Allgemeinen. Diese [Korrelationen] waren fur schnelligkeitsziffern ohne Anspornung und fur Genauigkeitsziffern mit Anspornung hoher

Warden und Cohen

THE DISCRIMINATION OF ABSOLUTE VERSUS RELATIVE SIZE IN THE RING DOVE, *TURTUR RISORIUS**

From the Animal Laboratory of the Department of Psychology, Columbia University

C. J. WARDEN AND C. N. WINSLOW[1]

The present experiment may be considered an extension of the work of Warden and Rowley (11) to the field of size discrimination The former study dealt with the nature of the cues in brightness discrimination under somewhat novel test conditions. In the usual discrimination test the training phase involves the simultaneous presentation of a pair of stimuli, and it has often been found that the animal, when tested later to other pairs differing in absolute value in the same dimension, responds to the relative rather than to the absolute aspect of the latter. This means, of course, that points of relative difference entered largely into the determination of the discrimination reaction in the case of the training pair. This type of response is often cited as an instance of the "relational judgment" by the Gestalt school. In the former study, attention was called to the possibility that this mode of response might be largely a function of the method of testing employed It is evident that the two-stimulus discrimination method, as usually applied, tends to favor the use of the relative rather than the absolute type of cue. The wide prevalence of this type of response may thus reflect the fact of a limited technique in testing discrimination instead of indicating a fundamental infra-human reaction type, as some have thought

In order to investigate this point, the usual discrimination test technique was modified, in both the present and the former study, in a manner intended to emphasize the value of the absolute aspects of the positive stimulus in the experimental situation. This was done by presenting, along with a constant positive stimulus, one or another of two negative stimuli, the one having a markedly lower value and the other a markedly higher value than the positive stimulus, with respect to the particular factor to be discriminated. In the study of

*Received in the Editorial Office September 15, 1931

[1]This experiment was planned and carried out in cooperation, the task of securing and tabulating the data being performed by the junior author The senior author is responsible for the report in its present form.

brightness, for example, the positive stimulus was always a medium gray (Hering No 26), while the negative stimulus might be either a very dark gray (Hering No 50) or a very light gray (Hering No 1) It is clear that a discrimination habit, if established at all under such conditions, cannot be based upon the relative aspects of the situation, since this is being reversed from trial to trial. The use of punishment for all responses to the negative stimulus, whether lower or higher in value than the positive stimulus, also tends to enhance the absolute aspect of the latter

The Yerkes-Watson vision apparatus was used in the present study, as formerly, and the general conditions obtaining were similar to those previously reported The apparatus was placed in a dark room and the reaction compartment illuminated by means of 3 Westinghouse *Mazda* bulbs (25-watt, 110-volts, frosted) centrally located above in such wise as to eliminate shadow effects. The birds soon learned to leave the darkened entrance compartment whenever the door leading into the lighted reaction compartment was raised The behavior of the doves was observed through a one-way light screen.

The three stimuli employed were equilateral triangles cut in acid blackened copper plates and, in general, of the usual type ordinarily used in this apparatus The triangle employed as the positive stimulus had an area of 11.691 sq cm and measured 5 196 cm on the side. The smaller of the other two triangles had an area of 7 0686 sq. cm and measured 3 0 cm. on the side, while the larger had an area of 28 2743 sq cm and measured 8 081 cm on the side It is clear, therefore, that the difference between the positive stimulus and either of the two negative stimuli was great enough so as not to present an especially difficult problem in discrimination to the birds In order to avoid position cues, the positive stimulus was shifted from side to side in the following irregular order *L, R, R, L, R, L, R, R, L, L, L, R, R, L, R* The control of temporal order, in the case of the negative set, was accomplished by presenting the larger or smaller in accordance with the following scheme. *S, L, S, L, S, L, L, S, S, S, L, S, L, S, L* The triangles were illuminated from behind by means of two identical lights located at points equidistant from the stimulus plates

The ring dove was used in this as in the former study The doves had been reared in the laboratory and were about four months of age at the beginning of the training period Training was begun

on four doves but two of these had to be discarded after the sixth week on account of the fact that they exhibited such consistent inactivity in the apparatus. In general, the same sort of difficulty formerly reported was experienced in the attempt to properly motivate the birds. The effect of starvation periods of the same length on activity apparently varies much more in the dove than in the chick or the white rat A starvation period of 48 hours was employed in the present study, and this did not seem to result in any impairment of health on the part of the birds In order to increase activity during the test, the plan was adopted of scattering a bit of food on the floor of the living cage in the presence of the birds before they were taken into the dark room for testing

Differential motivation was employed throughout the training, the reward consisting of a few grains of the regular food mixture following correct response, and the punishment being a suitable electric shock, administered by means of grills situated in front of the stimulus plates, as is usual in such tests The current was provided by the electrical system which has been described in connection with the Columbia Obstruction Apparatus (7), the E M F. reading at 700 volts and the multipoint switch being set at points 6, 7, and 8, in which case the current value is 2, 3, and 5 m.a , respectively At the beginning, unit 6 was employed, but it was found necessary to make use of units 7 and 8 in some cases as the experiment progressed in order to break up position habits. As a rule, the doves appeared to become easily adapted to a given intensity of shock, and even at the highest intensity employed did not appear to be frightened in the least. The food had to be placed fairly close to the positive stimulus, but always out of sight of the birds, because of the fact that doves tend to avoid the darkened food boxes farther back

The regular training was preceded by a preliminary period of adaptation to the situation consisting of five trials per day for six days During these trials punishment was not given and food was placed in both compartments of the apparatus. Two training periods per day were arranged, the one coming in the early forenoon and the other in the late afternoon, or early evening. The length of the training period varied considerably from day to day depending upon the general activity of the birds, which appeared to be determined in part by temperature and general climatic conditions. The daily schedule of trials is indicated in Tables 1 and 2.

TABLE 1

RECORD OF DOVE NO 1 (JANUARY 14 TO MAY 2, 1930)

Date		Exposure series	Larger variable Standard right R	W	Larger variable Standard left R	W	Smaller variable Standard right R	W	Smaller variable Standard left R	W	Total R	W
Jan	14	1 – 5	1			1	2			1	3	2
Jan	15	6 – 9	1			1	1			1	2	2
Jan	16	10 – 13	1			1	1			1	2	2
Jan	17	14 – 18	1			1	2			1	3	2
Jan	18	19 – 22	1			1	1			1	2	2
Jan	19	23 – 25	1			1	1				2	1
Jan	20	26 – 31	2	1		1	1			1	3	3
Jan	21	32 – 35	1			1	1			1	2	2
Jan	22	36 – 39	1			2	1				2	2
Jan	23	40 – 42				1	2				2	1
Jan	24	43 – 48	1			2	1			2	2	4
Jan	25	49 – 51	1				1			1	2	1
Jan	26	52 – 55	1			2	1				2	2
Jan	27	56 – 61	1			1	2			2	3	3
Jan	28	62 – 66	2				1			2	3	2
Jan.	29	67 – 71				2	2			1	2	3
Jan.	30	72 – 77	2		1		1			2	4	2
Jan	31	78 – 81	1			1	1			1	2	2
Feb	1	82 – 86	1			1	1			2	2	3
Feb	2	87 – 94	3			1	2			2	5	3
Feb	3	95 – 102	2			2	2			2	4	4
Feb.	4	103 – 109	2			2	1			2	3	4
Feb.	5	110 – 117	2			1	2		1	2	5	3
Feb	6	118 – 124	1	1		2	2			1	3	4
Feb	7	125 – 131	2				2			3	4	3
Feb	8	132 – 139	2			1	2			3	4	4
Feb	10	140 – 144	2			1	1			1	3	2
Feb	11	145 – 154	3			2	2			3	5	5
Feb	12	155 – 164	2			2	3			3	5	5
Feb	13	165 – 173	3			2	3			1	6	3
Feb	14	174 – 182	3			2	1			3	4	5
Feb.	15	183 – 188	2			1	2			1	4	2
Feb	17	189 – 197	2			2	3			2	5	4
Feb	18	198 – 206	3			1	2			3	5	4
Feb.	19	207 – 215	2			1	3			3	5	4
Feb	20	216 – 225	3			2	3			2	6	4
Feb	21	226 – 234	3			2	2			2	5	4
Feb	22	235 – 244	2			2	3			3	5	5
Feb	23	245 – 253	3			2	2			2	5	4
Feb	24	254 – 262	3			1	2			3	5	4
Feb.	25	263 – 270	2			2	3			1	5	3
Feb	26	271 – 281	3			2	2			4	5	6
Feb	27	282 – 292	3			2	3			3	6	5
Feb	28	293 – 304	2			3	4			3	6	6
Mar	1	305 – 314	3			2	3			2	6	4
Mar	2	315 – 322	3			1	2			2	5	3

TABLE 1 (*continued*)
RECORD OF DOVE NO 1 (JANUARY 14 TO MAY 2, 1930)

Date	Exposure series	Larger variable Standard right R	W	Larger variable Standard left R	W	Smaller variable Standard right R	W	Smaller variable Standard left R	W	Total R	W
Mar 3	323 – 331	2			2	2			3	4	5
Mar 4	332 – 340	2			2	3			2	5	4
Mar. 5	341 – 351	3			2	2			4	5	6
Mar. 6	352 – 363	2			3	4			3	6	6
Mar 7	364 – 375	3			3	3			3	6	6
Mar 8	376 – 387	4			2	4			2	8	4
Mar. 9	388 – 399	3			2	3			4	6	6
Mar. 10	400 – 411	4			2	2			4	6	6
Mar. 11	412 – 419				3	3			2	3	5
Mar. 12	420 – 429	3			1	2			4	5	5
Mar 13	430 – 441	4			3	3			2	7	5
Mar 14	442 – 452	3			1	3			4	6	5
Mar. 15	453 – 464	3			3	3			3	6	6
Mar. 16	465 – 477	3			3	3			4	6	7
Mar 17	478 – 491	4			3	4			3	8	6
Mar 18	492 – 505	3			3	4			4	7	7
Mar. 19	506 – 518	4			3	2			4	6	7
Mar. 20	519 – 532	4			2	4			4	8	6
Mar 21	533 – 542	3			2	3			2	6	4
Mar. 22	543 – 556	4			3	3	1		3	7	7
Mar 23	557 – 569	3			3	1	2	1	3	5	8
Mar 24	570 – 583	2		1	2	5			4	8	6
Mar 25	584 – 597	3	1	1	1	3	1	2	2	9	5
Mar 26	598 – 608	3		1	1	1	1		4	5	6
Mar 27	609 – 622	3	1		2	4			4	7	7
Mar 28	623 – 635	4			2	3		2	2	9	4
Mar. 29	636 – 648	2	1		3	4		1	2	7	6
Mar. 30	649 – 662	4			3	4			3	8	6
Mar 31	663 – 677	4			3	4		2	2	10	5
Apr. 1	678 – 692	4			3	4		1	3	9	6
Apr. 2	693 – 707	2	2	2	1	4		1	3	9	6
Apr 3	708 – 721	3			3	4		1	3	8	6
Apr 4	722 – 736	4			3	3	1		4	7	8
Apr. 5	737 – 750	4			2	4			4	8	6
Apr 6	751 – 765	3	1	1	2	4		2	2	10	5
Apr 7	766 – 780	4		1	2	4			4	9	6
Apr 8	781 – 795	4		1	2	4		3	1	12	3
Apr. 9	796 – 810	2	2	1	2	3	1	4		10	5
Apr 10	811 – 825	3	1		3	3	1	1	3	7	8
Apr 11	826 – 840	4		1	2	4		2	2	11	4
Apr 12	841 – 855	3	1		3	4			4	7	8
Apr 13	856 – 870	4			3	4			4	8	7
Apr 14	871 – 885	4		1	2	3	1		4	8	7
Apr. 15	886 – 900	3	1		3	4			4	7	8
Apr. 16	901 – 915	2	2	1	2	4		3	1	10	5
Apr 17	916 – 930	3	1	1	2	4		2	2	10	5

TABLE 2

RECORD OF DOVE NO 2 (JANUARY 18 TO MAY 1, 1930)

Date		Exposure series	Larger variable Standard right R	W	Standard left R	W	Smaller variable Standard right R	W	Standard left R	W	Total R	W
Jan	18	1 – 5	1			1	1	1		1	2	3
Jan.	19	6 – 9		1		1	1		1		2	2
Jan	20	10 – 14		1	1		1		2		4	1
Jan	21	15 – 19	2			1	1		1		4	1
Jan	22	20 – 24		1		1	1	1	1		2	3
Jan	23	25 – 30	1	1	1			1	1	1	3	3
Jan	24	31 – 36	1		1	1	1	1		1	3	3
Jan	25	37 – 42		1	1		2		2		5	1
Jan	26	43 – 48	1	2			1			2	2	4
Jan	27	49 – 54		1		2	2		1		3	3
Jan	28	55 – 60	1	1	1		1		1	1	4	2
Jan	29	61 – 66		1	1	1	2			1	3	3
Jan.	30	67 – 70	1					1	1	1	2	2
Jan	31	71 – 78	2	1		1	2		1	1	5	3
Feb	1	79 – 86		1	1	2	1	1	2		4	4
Feb	2	87 – 94	3			1	1	1	1	1	5	3

TABLE 1 (*continued*)

RECORD OF DOVE NO. 1 (JANUARY 14 TO MAY 2, 1930)

Date		Exposure series	Larger variable Standard right R	W	Larger variable Standard left R	W	Smaller variable Standard right R	W	Smaller variable Standard left R	W	Total R	W
Apr	18	931 – 948	5		1	2	5			5	11	7
Apr	19	949 – 966	3	1		5	5			4	8	10
Apr.	20	967 – 984	5		1	2	5		2	3	13	5
Apr	21	985 – 1002	4		2	2	4	1	2	3	12	6
Apr	22	1003 – 1020	3	3	2	1	4		2	3	11	7
Apr	23	1021 – 1040	5		1	3	6			5	12	8
Apr	24	1041 – 1060	5			4	5		3	3	13	7
Apr.	25	1061 – 1080	6		1	3	5		1	4	13	7
Apr.	26	1081 – 1100	5		3	1	6		2	3	16	4
Apr.	27	1101 – 1108	2		1	1	1	1		2	4	4
Apr	28	1109 – 1128	6		2	1	4	1	2	4	14	6
Apr.	29	1129 – 1148	5	1	2	2	5		3	2	15	5
Apr	30	1149 – 1169	4	1	4		4	1	5	2	17	4
May	1	1170 – 1190	6		1	3	6		4	1	18	3
May	2	1191 – 1200	2	1	2		2		3		9	1
Total		1200	297	23	37	202	306	13	58	264	698	502
Cardboard forms		1 – 25	6		2	3	7		5	2	20	5

TABLE 2 (*continued*)

RECORD OF DOVE NO 2 (JANUARY 18 TO MAY 1, 1930)

Date		Exposure series	Larger variable Standard right		Larger variable Standard left		Smaller variable Standard right		Smaller variable Standard left		Total	
			R	W	R	W	R	W	R	W	R	W
Feb.	3	95 – 102		1	1	1	2	1		2	3	5
Feb.	4	103 – 110	3			1	1	1		2	4	4
Feb.	5	111 – 118	2		1	1	2			2	5	3
Feb	6	119 – 126	2			2	2			2	4	4
Feb	7	127 – 134	2			1	2			3	4	4
Feb	8	135 – 142	2	1	1	1	1	1		1	4	4
Feb	9	143 – 150	2			1	2		2	1	6	2
Feb	10	151 – 158	2			2	3			1	5	3
Feb.	11	159 – 168	3			1	2		1	3	6	4
Feb	12	169 – 178	2			3	2	1		2	4	6
Feb.	13	179 – 188	3			2	3		1	1	7	3
Feb	14	189 – 198	3			1	2			4	5	5
Feb	15	199 – 208	2			3	3			2	5	5
Feb.	16	209 – 218	3			2	2	1		2	5	5
Feb.	17	219 – 228	3			1	2			4	5	5
Feb	18	229 – 238	2			3	3			2	5	5
Feb	19	239 – 248	3			2	3			2	6	4
Feb.	20	249 – 258	3			1	2		1	3	6	4
Feb	21	259 – 268		2	1	2	1	2	2		4	6
Feb.	22	269 – 278	3		1	1	1	2	1	1	6	4
Feb.	23	279 – 288	1	2		1	1	1	2	2	4	6
Feb	24	289 – 298	1	1	1	2	1	2		2	3	7
Feb.	25	299 – 306	2			2	2			2	4	4
Feb.	26	307 – 317	1	3	1			2	2	2	4	7
Feb	27	318 – 328	2		1	2	3	1		2	6	5
Feb	28	329 – 338	1	2		2	3		2		6	4
Mar	1	339 – 348	3		1			2	3	1	7	3
Mar	2	349 – 358	1	1	2	1	2	1	1	1	6	4
Mar.	3	359 – 368	1	2		2	1	2	2		4	6
Mar	4	369 – 378	2	1	1	1	1	1	3	1	7	3
Mar.	5	379 – 390		3		3		3	2	1	2	10
Mar	6	391 – 402		2	3		1	3	2	1	6	6
Mar	7	403 – 414	2	2	2		2	1	2	1	8	4
Mar.	8	415 – 426	1	2	2	1	1	2	2	1	6	6
Mar.	9	427 – 438	2	2	1		2	1	2	2	7	5
Mar	10	439 – 450	2	1	2	1	1	2	3		8	4
Mar	11	451 – 462	1	1	1	2	1	3	1	2	4	8
Mar.	12	463 – 474	2	2		2	1	2		3	3	9
Mar	13	475 – 486	2	1		3	2	1	1	2	5	7
Mar	14	437 – 498	4		1		1	2	3	1	9	3
Mar	15	499 – 510		2	4			4	2		6	6
Mar.	16	511 – 524	1	2	2	1	1	3	1	3	5	9
Mar.	17	525 – 538	1	3	2	1	2	2	2	1	7	7
Mar.	18	539 – 552	3			3	2	2		4	5	9
Mar.	19	553 – 566	2	2	2	1	1	2	1	3	6	8
Mar	20	567 – 580	1	3	1	1		4	3	1	5	9

TABLE 2 (*continued*)
RECORD OF DOVE NO 2 (JANUARY 18 TO MAY 1, 1930)

Date		Exposure series	Larger variable Standard right R	Larger variable Standard right W	Larger variable Standard left R	Larger variable Standard left W	Smaller variable Standard right R	Smaller variable Standard right W	Smaller variable Standard left R	Smaller variable Standard left W	Total R	Total W
Mar	21	581 – 594	1	3	3		1	3	2	1	7	7
Mar	22	595 – 608	1	3	1	2	1	3	2	1	5	9
Mar.	23	609 – 622	3	1	2	1	2	1	3	1	10	4
Mar	24	623 – 636		3	3			4	3	1	6	8
Mar	25	637 – 650	3	1	1	1	2	2	1	3	7	7
Mar	26	651 – 664	3	1	3		2	1	3	1	11	3
Mar	27	665 – 678	3	1		2	2	2	1	3	6	8
Mar	28	679 – 692	4		2	1	2	1	2	2	10	4
Mar	29	693 – 706	1	2	2	1	2	2		4	5	9
Mar	30	707 – 720	1	3		3	2	2	1	2	4	10
Mar	31	721 – 735	3	1	2	1	4		1	3	10	5
Apr	1	736 – 750	3	1	1	2	2	2	1	3	7	8
Apr.	2	751 – 765	3	1	2	1	2	2	1	3	8	7
Apr	3	766 – 780	3	1		3	1	3		4	4	11
Apr	4	781 – 795	3	1	1	2	4			4	8	7
Apr	5	796 – 810	3	1	1	2	3	1	1	3	8	7
Apr	6	811 – 825	4			3	3	1	2	2	9	6
Apr	7	826 – 840	4		1	2	3	1		4	8	7
Apr.	8	841 – 855	4			3	4			4	8	7
Apr	9	856 – 870	3	1	1	2	4		1	3	9	6
Apr	10	871 – 885	4			3	2	2	1	3	7	8
Apr.	11	886 – 900	3	1	2	1	4		1	3	9	6
Apr	12	901 – 915	4		1	2	4		1	3	10	5
Apr	13	916 – 930	4		1	2	4		1	3	10	5
Apr.	14	931 – 945	3	1	2	1	4		1	3	10	5
Apr	15	946 – 960	4		1	2	1	3	2	2	8	7
Apr	16	961 – 975	2	2	1	2	3	1	1	3	7	8
Apr	17	976 – 990	3	1		3	3	1	1	3	7	8
Apr.	18	991 – 1008	5		1	2	4	1		5	10	8
Apr	19	1009 – 1026	3	1	3	2	5		1	3	12	6
Apr	20	1027 – 1044	4	1		3	3	2	1	4	8	10
Apr	21	1045 – 1062	3	1	2	2	4	1		5	9	9
Apr	22	1063 – 1080	4	2		3	2	2	1	4	7	11
Apr	23	1081 – 1095	4		1	2	4			4	9	6
Apr.	24	1096 – 1110	4			3	4			4	8	7
Apr	25	1111 – 1125	3	1	1	2	4			4	8	7
Apr	26	1126 – 1140	4			3	4		2	2	10	5
Apr	27	1141 – 1148	2			2	3		1		6	2
Apr.	28	1149 – 1163	4		1	2	3	1		4	8	7
Apr	29	1164 – 1178	2	2	1	2	4		3	1	10	5
Apr	30	1179 – 1193	3	1	2	1	4		2	2	11	4
May	1	1194 – 1200	2	1			1		1	2	4	3
Total		1200	224	96	88	152	211	110	111	208	634	566
Cardboard forms		1 – 25	4	2	3	2	6	1	3	4	16	9

In order to eliminate any possible cues from the particular set of stimulus plates employed, the following controls were introduced. (*a*) either side of the plates (both sides being acid blackened) was presented indiscriminately during the training, (*b*) a second set of copper plates was substituted for the original training set from Trial 1000 to Trial 1175, the first set being then used for the last 25 trials of the 1200-trial training period, and (*c*) a control series of 25 trials, in which carefully prepared cardboard forms were substituted for the copper plates, was run after the completion of the training period As Johnson (8) has pointed out, the luminosity factor varies under the conditions of testing size discrimination on the Yerkes-Watson apparatus While no control tests were run to

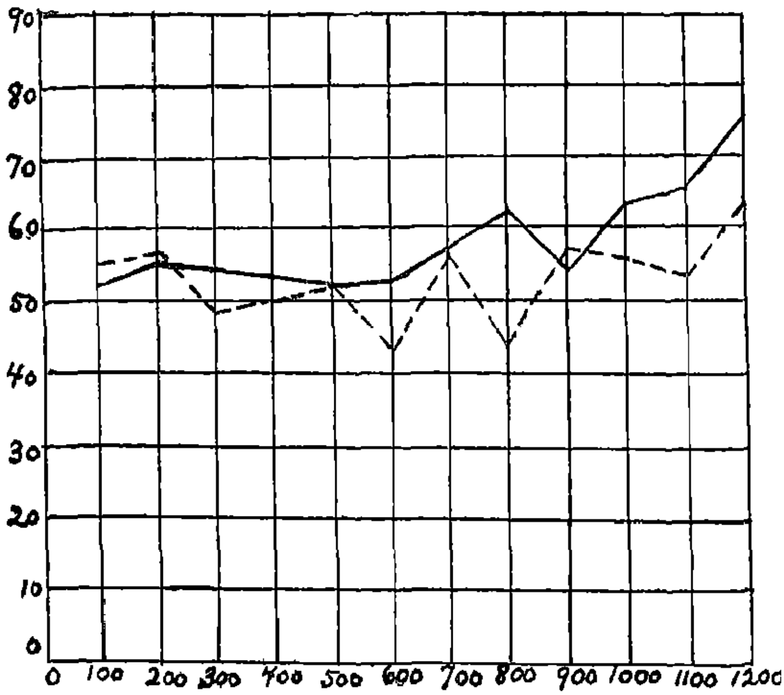

FIGURE 1

PERCENTAGE OF CORRECT RESPONSES

Trials are shown on abscissa and percentage of correct responses on ordinate. Solid line=dove No 1, broken line=dove No 2

check against this factor, the relative luminosity of the negative stimulus was necessarily reversed whenever the large and small plates were interchanged, and therefore control tests were not required under the conditions. Since the substitution of plates, as mentioned above, was ineffective in increasing the error score, and since the proper precautions were taken with respect to other possible sources of error, it seems evident that the doves were responding upon the basis of size difference.

The daily records of the two birds are detailed in Table 1 and 2, and the percentage of correct responses for each successive hundred trials shown in connection with the graph of Figure 1. It will be noted that dove No. 1 gave little evidence of forming the discrimination habit until about the 700th trial, and not very definitely until after the 1000th trial. Thereafter the curve rises rapidly up to the point of 76% correct and, from all appearances, might have gone still higher had the training been continued. The record of dove No. 2 is less satisfactory because of frequent relapses, due in the main to position habits. At the end of the training series, it was making only 62% correct choices, the most gain being shown on the last hundred trials, which suggests that further training would probably have led to an improved score. It should be noted that these final scores are based upon averages for 100 trials and not, as is usual upon 10 or 20 trials, and for this reason must be regarded as more dependable than most final performance scores in discrimination tests. If the record of the last two days of the training period be taken, instead, as the basis of computing the final score, both of the doves make a much better showing. Of the 31 trials given on the last two days, in the case of dove No. 1, 27 responses, or 87%, were correct, while on the last day 9 trials out of 10 were correct. Of the 22 trials given on the last two days to dove No. 2, 15 responses, or 68%, were correct. As measured by the usual norms of mastery in discrimination work, the results thus appear to be typical in every respect, unless it be in the matter of the relatively large number of trials required to set up the habit.

In the former study there was evidence of some slight preference for the lighter of the two stimuli, but in the present case there appeared to be no tendency to go to one of the negative stimuli more than to the other. The facts covering this point are shown in the graph of Figure 2. In 589 trials, or 49% of the total of 1200 trials, dove No. 1 made a positive response to the larger of the triangles

presented, and the corresponding figures for dove No 2 are 570 trials, or 47.5%. This is as near a chance distribution of responses as could be expected in so short a series This means that under the present conditions, in which the absolute aspects of the positive stimulus were emphasized in much the same manner as the relative factor is emphasized under the usual two-stimulus method, the birds showed no tendency whatsoever to make use of cues of the relative type

The results of both this and the former study may be considered as so much evidence in favor of the view that the so-called "relational judgment" is in large part a function of the specific technique of the two-stimulus discrimination method, rather than the fundamental

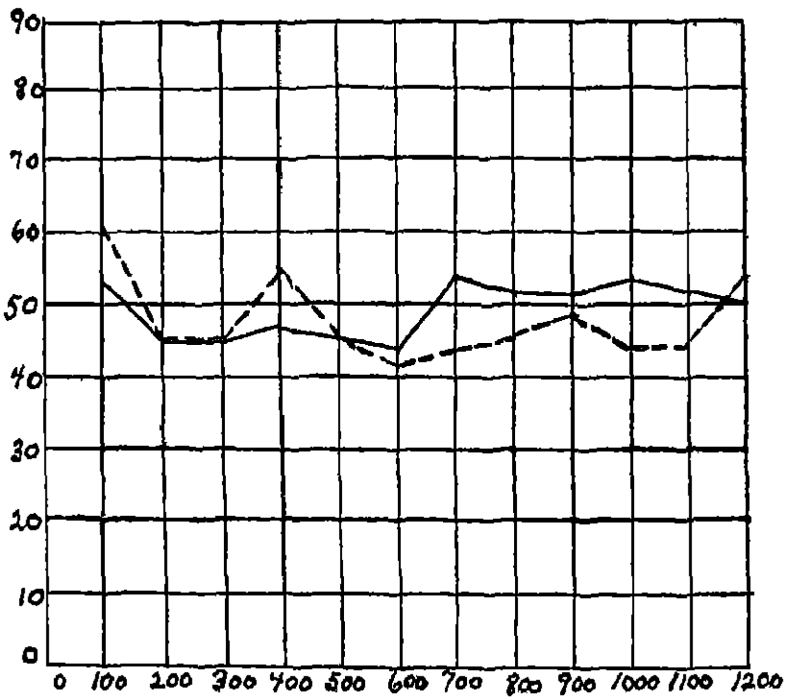

FIGURE 2

PERCENTAGE OF RESPONSES TO THE LARGER VARIABLE

Trials are shown on abscissa and percentage of responses to larger triangle on ordinate Solid line=dove No. 1, broken line=dove No 2

reaction-type that it is supposed to be in some quarters. When the mode of presentation is such that the relative type of cue is emphasized, discrimination habits are likely to be based upon such factors. However, when the mode of presentation is such as to emphasize the absolute type of cue, discrimination habits tend to be based upon these factors. This interpretation is supported by the work of Washburn (12), Johnson (8), and Gayton (6), in which the usual two-stimulus method was complicated in a somewhat similar manner, and in which absolute cues were found to be more or less operative as a natural result The claim so often made that the "relational judgment" is more typical or natural than the response to absolute characteristics of the stimuli may also be called in question Either seems to be typical and natural under different conditions of testing. It may be that an animal in its natural environment is less often required to make use of absolute than relative stimulus characteristics, but no one has ever shown this to be the case, and it cannot be taken for granted.

The recent criticism of Perkins and Wheeler (10) of the former paper by Warden and Rowley (11) should perhaps be mentioned in this connection. As pointed out by Warden in the above article, the work of the Gestalt psychologists on this type of the so-called "relational judgment" in animals was antedated many years by similar and better controlled tests by the following American comparative psychologists, here listed in chronological order: Kinnaman (9), Casteel (4), Breed (3), Washburn and Abbott (12), Bingham (1, 2), Coburn (5), and Johnson (8). Kinnaman, who first observed it, evidently regarded it as judgmental in nature for he goes so far as to say that it probably indicated "a general notion, of a low order, which might be represented by food-always-in-the-lighter" in connection with brightness tests on monkeys. This sounds strangely like the later Gestalt interpretations of the phenomenon, although the term "relational judgment" is not specifically used It seems reasonable to suppose that a concept, even of a low order, would be regarded as involving "insight" by psychologists of any of the subjective schools Johnson also appeared to make much of this type of response, rating it as probably higher than a response based upon absolute brightness value

While it is true that American investigators have not founded a school of psychology on the basis of this and related types of response, it is idle to say that they have ignored it, or that their results were

"incidental and unsystematic" As a matter of fact, the most systematic and controlled results on the problem are those of these early American investigators, since the foreign work referred to in the former article was quite uncontrolled in a number of important ways, as there pointed out. Furthermore, I know of no American psychologists who are "howling for credit" in this connection as Perkins and Wheeler declare I consider it rather unfortunate, however, that the matter of priority has become confused in this and other instances because the Gestalt group of animal workers have shown a disposition to ignore the American work, and have presented their results as discoveries of unusual importance, when, as a matter of fact, their findings, in this case at least, were neither new nor of special importance

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LA DISCRIMINATION DE GRANDEUR ABSOLUE ET DE GRANDEUR RELATIVE CHEZ LE PIGEON TUTUR RISORIUS

(Résumé)

On a entraîné des pigeons à discriminer dans des conditions qui ont favorisé l'emploi des suggestions absolues en contraste avec la méthode ordinaire de deux stimuli laquelle favorise l'emploi des suggestions relatives. On a employé un stimulus positif composé d'un triangle de grandeur moyenne, et deux stimuli négatifs, l'un un très petit triangle et l'autre un très grand, le stimulus positif étant présenté avec tantôt l'un stimulus negatif et tantôt l'autre L'habitude a éte établie dans ces conditions, ce qui suggère que le soi-disant "jugement relationnel" des psychologues de la Gestalt, en tant qu'il s'agit de la discrimination chez les animaux, est au moins en partie une fonction de la méthode de deux stimuli ou presente deux paires en même temps, puisqu'on ne l'obtient que quand on emploie cette méthode-ci.

WARDEN ET WINSLOW

UNTERSCHEIDUNG VON ABSOLUTER IM GEGENSATZ ZUR RELATIVEN GRÖSSE BEI DER RINGELTAUBE, TURTUR RISORIUS

(Referat)

Es wurden Ringeltauben in der Unterscheidung dressiert, unter Verhaltnissen, welche den Gebrauch von absoluten im Gegensatz zu relativen Weisungen ("cues") begunstigten Ein positiver Reiz, bestehend aus einem Dreieck von mittelmassiger Grosse, und zwei negative Reize, der eine aus einem sehr kleinen, der andere aus einem sehr grossen Dreieck bestehend, wurden gebraucht Der positive Reiz wurde nun mit einem, nun mit dem anderen negativen Reiz dargeboten Die Gewohnheit formte sich unter diesen Verhaltnissen, welche andeuten, dass das so-genannte "Beziehungsurteil" ("relational judgment") der Gestaltpsychologie was die Arbeit an Unterscheidung bei Tieren anbelangt, wenigstens teilweise eine Funktion der Methode-mit-zwei-Reizen ("the two-stimulus method"), ist, wobei Paare zu gleicher Zeit dargeboten werden, da diese Urteilsform nur bei Gebrauch dieser letzteren Methode erhalten wird

WARDEN UND WINSLOW

AN APPARATUS FOR TESTING VISUAL DISCRIMINATION IN ANIMALS*

From the Psychological Laboratory of the University of Pittsburgh

NORMAN L. MUNN[1]

INTRODUCTION

The Yerkes-Watson apparatus (17) for testing animal discrimination has recently been subjected to criticism from Fields (2) and Lashley (6). Both of these experimenters have offered apparatus to take the place of that of Yerkes and Watson

Fields (2) criticized the Yerkes-Watson device because of its needless complexity and because it does not take account of the focalizing abilities of an animal Fields' own apparatus had the advantage of being simpler than that of Yerkes and Watson. Furthermore, it enabled the animal to come within close proximity of the stimuli before being called upon to make a discrimination In the Yerkes-Watson apparatus it had not been possible, even after 1000 trials, to demonstrate evidence of good pattern vision in the rat. In Fields' apparatus what seemed like evidence of good pattern vision could be obtained in 800 trials. Because of several defects in Fields' apparatus, defects which offered the possibility of a discrimination by extraneous cues such as size, brightness, handling, cutaneous cues, and cues from the operation of the apparatus, I was forced to contest the finality of Fields' results on pattern vision (7) Using a modification of Fields' apparatus, in which the above-mentioned extraneous cues were controlled from the outset, I could not, in 1200 trials, obtain any positive evidence of pattern vision in rats (9) or in raccoons (8). The results did not differ from those which I had obtained with the Yerkes-Watson apparatus Fields (4) answered some of my criticisms, and I replied (11), but our discussion did not bring a solution to the problem in which we were both interested, viz, whether rats could or could not discriminate visual patterns of equal area and brightness The solution came from Lashley (6).

*Accepted for publication by Walter S Hunter of the Editorial Board and received in the Editorial Office, September 22, 1930

[1]I am indebted to Dr Davenport Hooker of the Department of Anatomy of the University of Pittsburgh for providing the space and the animals which made this research possible

Shortly after the above-mentioned discussion, I received from Lashley plans of a new apparatus by means of which he had obtained evidence of good pattern vision in rats in from 20-60 trials. At Lashley's request, I repeated his experiment in part and amply verified his results

During a discussion concerning Lashley's apparatus, Dr Walter S. Hunter suggested that I should undertake to ascertain why Lashley's apparatus yields in 20-60 trials what the Yerkes-Watson apparatus does not yield in over 1000 trials I undertook to do this by means of a gradual modification of the Yerkes-Watson apparatus. The result is an apparatus which combines features of Lashley's and Fields' apparatuses, which yields results comparable with those of Lashley's apparatus, which requires much less preliminary training than does Lashley's technique, and which can be used with animals not adapted to Lashley's apparatus. Incidently, this apparatus throws some light upon the reason for the difference in results between the Yerkes-Watson apparatus and the Lashley apparatus.[2] Before discussing this new apparatus, a brief discussion of the main features of the Yerkes-Watson and Lashley apparatuses will be advisable In the Yerkes-Watson apparatus the animal enters a discrimination chamber where it is confronted by two stimuli, each of which appears at the end of a short alley *If the animal approaches the "positive"* stimulus, he is allowed to *pass before* the stimulus and enter a side alley which leads him back to the entrance box where food is obtained. If he approaches the "negative" stimulus, however, he is given a slight electric shock, is prevented from entering the food-entrance box, and is required to retrace his steps and go via the correct route. The closeness with which the animal may approach the stimuli before having to discriminate between them is determined by a partition which separates them The length of this partition may vary from several inches to several feet, depending upon the size of the apparatus and the desire of the experimenter. The stimuli are usually emitted from a light box behind the discrimination chamber

[2]The apparatus to be presented in this paper is similar, in some respects, to an apparatus used by Washburn and Abbott (13) to test the brightness value of red for the light-adapted eye of the rabbit Their apparatus consisted of two equal compartments. On the front of each compartment was a door, pivoted so as to swing on a horizontal axis, on which the stimulus to be discriminated appeared The animal pushed the lower part of the door with its nose If the response as correct, the animal obtained food *behind the door* The "incorrect" door was locked

ber. Reflected light may be used, however. The electric shocking device is not an essential part of the apparatus. When shock is not used, the long and devious path to the food-entrance box is considered sufficient "punishment" for an incorrect response.

Lashley's apparatus consists of two parts, a platform from which the animal *jumps against* the stimuli, and devices for presenting the stimuli and punishing or rewarding the animal. The rat is placed on a circular platform raised several feet from the floor. Directly opposite the jumping platform, at a distance of 25 cm, is a frame containing two apertures in each of which appears a stimulus to be discriminated. The cards on which the stimuli appear are placed behind the apertures and held in place either by a light spring or a rigid turnbutton. If the rat *jumps against* the "positive" stimulus, the light spring arrangement allows the card to fall and the rat finds food on a platform placed behind the stimuli. If he jumps against the "negative" stimulus, however, the rigid turnbutton holds the card in place and the rat falls into a net some two or three feet below. Before the experiment proper may begin, it is necessary to train the animal to jump. The jumping platform is placed against the two apertures and the rat runs from this platform through either aperture, to the food platform. Here he finds food at a point equidistant from both apertures. After the animal has learned to run through the openings and obtain food, the jumping platform is gradually removed from the food platform. Soon the rat must jump in order to obtain food. After the animal has successfully learned to jump a distance of 25 cm from the edge of the platform through either aperture, one of the apertures is blocked and the animal is required to jump through the open one. He usually does this without further training. After the open aperture has been changed from side to side a few times and the rat has successfully negotiated the jump, a white card is placed in one opening and a black card in the other. The rat usually jumps without training to the white card. The stimuli to be discriminated are now presented. Lashley found that hooded rats, in from 20-60 trials, learn to discriminate between triangles differing with respect to the position of their apices and between patterns composed, respectively, of horizontal and vertical lines. Several other patterns were successfully discriminated. Size discrimination was also obtained. White rats could also discriminate, but their visual acuity was less than that of hooded rats.

It will be seen that the essential factors which differentiate Lash-

ley's technique from the technique of Yerkes and Watson are as follows. (*a*) The animal, instead of merely running *toward* and *around in front of* the stimuli to be discriminated, *jumps directly against them.* Whereas the Yerkes-Watson technique does not guarantee that the animal will be effectively stimulated by the lights at the end of the discrimination chamber[3] Lashley's technique does, at least, guarantee that the "foodseeking" activity of the animal shall be centered on the stimuli themselves. The chief activity manifested in the Yerkes-Watson apparatus is that of running through alleys which have no *essential* connection with the stimuli to be discriminated In the Lashley apparatus *all* activity is centered on the stimuli (*b*) In Lashley's apparatus there is a close temporal and spatial proximity between the punishing and rewarding factors and the act of discrimination. If the response is incorrect, the animal falls *immediately* If the response is correct, the animal is *immediately* rewarded In the Yerkes-Watson apparatus a rat obtains food some 2 seconds (9) after passing before the correct stimulus Unless an electric shock is used in the Yerkes-Watson apparatus (in which case there *is* a close proximity between an incorrect response and punishment), the animal "learns" of the incorrectness of his response approximately 2 seconds after the response has been made. That is, he must run through the side alley leading to the food-entrance box exactly as though a correct response has been made, it is not until he finds the closed door preventing entrance to the food box that the incorrectness of the response can become apparent (This also happens with shock unless the current is strong enough to make the rat turn back immediately after stepping upon the grill.) (*c*) In Lashley's apparatus there is an enforced *pause* before the animal makes his response In the Yerkes-Watson apparatus, on the other hand, the animal may run indiscriminatingly toward one stimulus or the other A pause naturally heightens the possibility that the animal will be effectively stimulated by the objects to be discriminated.

The partition which, in the Yerkes-Watson apparatus, determines how close the animal may come to the stimuli before being called upon to discriminate between them, is not an essential difference between the two apparatuses. Lashley's rats are 25 cm from the

[3]Lashley (5), in an early experiment with the Yerkes-Watson apparatus, recognized this difficulty and attempted to overcome it by using a flicker device to attract the "attention" of the animals to the forms to be discriminated

stimuli when they are called upon to discriminate. (Of course, they reach out with their heads over the edge of the jumping platform, and thus get closer to the stimuli than the distance of the platform itself However, the partition in the Yerkes-Watson apparatus may be so short that the animals may approach within 10-15 cm. of the stimuli, yet they cannot learn to discriminate (9). In the apparatus to be described here, however, some experiments were successfully carried out with a partition, exactly the same as that existing in the Yerkes-Watson apparatus, which had a length of 12.5 cm)

The use of reflected light in Lashley's apparatus does not differentiate it from the Yerkes-Watson apparatus where emitted light is most often used Yerkes (16) and Waugh (15) have used the Yerkes-Watson apparatus with reflected light, i e, with cards as stimuli, and have obtained nothing but negative results on pattern discrimination in mice.

It may be thought that an important factor which differentiates Lashley's technique from the Yerkes-Watson technique is the type of punishment used. That is, a fall may be considered a more natural, and hence more effective, form of administering punishment than an electric shock. That this does not explain the difference in results obtained on the two types of apparatus is apparent when, in the apparatus to be described, shock was used (as in the Yerkes-Watson apparatus) with results as effective as those obtained by means of Lashley's apparatus

The apparatus shortly to be described is similar to Lashley's only in that the animal responds *directly* to the stimuli to be discriminated and in that the punishing and rewarding factors are *immediately* administered The animal *runs against* the stimulus [somewhat like the rabbits in Washburn and Abbott's experiment (13)] instead of jumping against them as in Lashley's apparatus. Furthermore, punishment is principally an electric shock whereas, in Lashley's apparatus, it is a fall. In Lashley's apparatus there is an *absolute* deprivation of food following an incorrect response. In the present apparatus, however, an incorrect response only *delays* food-getting If Fields (2) had required his rats to run directly against the stimuli used in his apparatus, instead of under them, his apparatus and the present one would have been quite similar in their general features. The present apparatus, then, contains little that is not already present in the apparatus of Washburn and Abbott (13), Yerkes and Watson (17), Fields (2), and Lashley (6) I have merely com-

bined certain of the features of the above apparatus and the result is, I believe, an apparatus having advantages which, individually, none of the above offers. Since it gives results which cannot be obtained by means of the Yerkes-Watson and the Fields apparatus, one has merely to show in what respects it has advantages not found in Lashley's apparatus, an apparatus yielding comparable results

The chief difficulty with the Lashley apparatus, as I see it, is the jumping technique In the first place, it requires a long period of preliminary training which, in the present apparatus, is not necessary In the second place, one finds many rats refusing to jump towards the stimuli (especially after they have fallen a few times) unless they were pushed from the platform, or unless their tails are struck. Unless one interferes in this way, much time is consumed in carrying out the experiment. (Of course, the top of the jumping platform could be made into an electric grill. This, however, would needlessly complicate the conditions) In my repetition of Lashley's experiment (10) I started the preliminary training with seven rats. Only two of these animals ever reached the point where, without interference from me, they would jump to the stimuli. One of them took so long to jump that I discontinued using him The other animal completed the entire experiment without such difficulties. In the present apparatus I started the experiment with 13 rats. One died, but all of the other rats completed the experiment. The preliminary training took approximately 10-20 minutes on each of two consecutive days In the third place, many animals will not jump in the manner required by Lashley's technique. [In my experiment with chickens (12), although I had used Lashley's apparatus with rats, I was forced to fall back on the Yerkes-Watson apparatus because chickens could not be adapted to the Lashley technique] In Lashley's apparatus it is practically impossible to confine the animal. Such confinement is necessary with some animals less subject to handling than rats. I am thinking particularly of birds, raccoons, dogs, etc.

None of this discussion is to the discredit of Lashley's important contribution. These facts are mentioned merely to show that his technique offers certain difficulties, especially with animals other than rats, which the present technique does not offer.

Apparatus and Technique

The apparatus is pictured in Figures 1-3 The general plan is

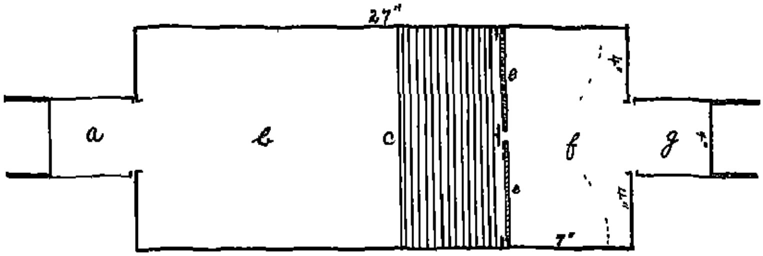

FIGURE 1

GROUND PLAN OF THE APPARATUS

a and *g* are boxes for handling the animals *b*, discrimination chamber *c*, electric grid *e*, doors in which the stimuli to be discriminated appear These open toward the rear of the apparatus as pictured in the dotted lines The apparatus is 12 inches in height

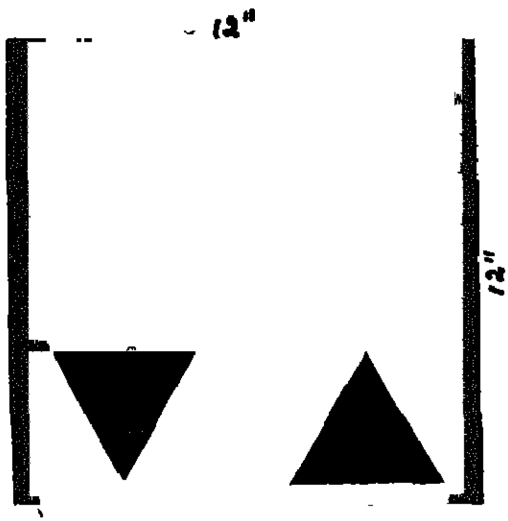

FIGURE 2

THE STIMULI AS THEY APPEAR FROM WITHIN THE APPARATUS

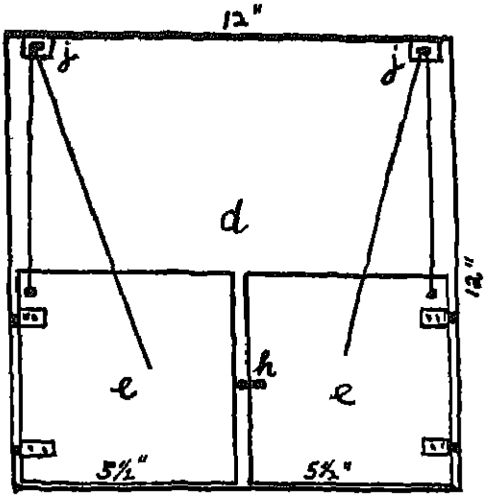

FIGURE 3

Back of Partition in Which Stimuli Appear

This is a back view of Figure 2 *e*, doors in which the stimulus cards are placed *h*, a set screw which locks either door *j*, piece of brass to which the two pieces of spring steel, causing the door to close and prevent a return into the apparatus, are soldered The doors are 5 5 inches on the side The bottom and both sides of the doors are grooved to permit entrance of a card The aperture behind which the cards appear is 5 25 inches square

similar, in many respects, to that of Fields' apparatus (2), while the method of presenting the stimuli is not unlike the method used by Lashley (6) and by Washburn and Abbott (13) The walls and the partition, *d*, were made of three-ply wood and painted a dull black. The doors, *e*, which contained the stimulus cards, were made from thin aluminum and hinged to the outer edges of the partition, *d*, by means of small brass hinges. They were slightly larger than the apertures in the partition, and they opened toward the rear of the apparatus The springs, which caused the door to close after the animal had pushed it open, were made of two pieces of spring steel wire soldered to a brass plate, *j* One of the wires was soldered to the top of the door, the other wire was free at its lower end (see Figure 3) By bending the free wire towards the center of the door, the amount of resistance could be increased The spring device served to keep the aluminum door and its stimulus card firmly

against the aperture It also prevented the animals from entering the discrimination chamber from the rear of the apparatus since it caused the door to close as soon as an animal had passed through the aperture. In each door was a slot which allowed the card to be inserted or withdrawn with ease The small brass turnbutton, *h*, locked the door which contained the negative stimulus The stimuli were changed from side to side in a chance order either by withdrawing the cards and interchanging them or, in the case of the triangles, by inverting each card. The cards containing the vertical and horizontal stripes were turned 90° in order to switch the stimuli from side to side In this way the *identical* card called out a negative response in one trial and a positive response in another. The light which illuminated the patterns and the apparatus was a 100-watt bulb placed in the apparatus above the entrance point and shaded to throw the light toward the stimuli The electric grid was connected with the regular 110-volt circuit through the 1775-ohm, 5-amp. Jagobi rheostat

The triangular stimuli were carefully cut from white paper and pasted on pieces of black cardboard which fitted into the grooves of the doors The striped patterns were made by painting black stripes of 1-cm. width on white cardboard. There was no reflection of the patterns on the floor. The floor of the apparatus itself was a piece of unpainted three-ply wood.

The method of procedure was as follows: Both doors of the apparatus were open and food was place in the box *g*. The animal was brought from the animal room in a box identical in all respects with the box in which the food was placed. This box, *a*, was placed at the entrance to the discrimination chamber, *b* The rat explored the apparatus and eventually reached the food box, *g*. While he was eating the small piece of bread and milk which he found there, the box, *a*, was substituted for the box, *g*, and the latter box, still containing the rat, was placed at the entrance of the discrimination chamber. By using two boxes in this manner it was never necessary to handle the animals directly. After the animal (who had been deprived of food for approximately two days) had run through the apparatus and obtained food about 4 or 5 times, I closed one of the doors After he had run through the open door a few times (it was changed from side to side to avoid a position habit), both doors were closed, but neither of them was locked. The animal explored and finally pushed against one of the doors. The

door readily opened, and he obtained food as before. (If the animal did not push against the door within a minute or so, I pushed him against it with a stick.) After the animal had learned to run against the door (requiring about 4 trials), one door was locked. (Neither door yet contained a stimulus card.) Most of the animals, when they pushed on the door which was locked, began to tear madly at it, but finally they tried the other door. After 6-10 trials with one of the doors locked, a black card was placed in one door and a white card in the other. Unlike Lashley's rats, my animals did not respond without training to the white card. If they ran across the grid and approached the white stimulus, I allowed them to push against the door and run to the food box. If they approached the black card, however, they were given a shock and they found that the door could not be opened. They then turned and entered the other door. *A response was considered incorrect once the animal had touched the wrong door.* He had to learn to discriminate *without touching* the doors before he was considered to have learned the problem. After the black-white discrimination had been learned, some of the animals were placed on the horizontal-vertical–pattern problem, others on the triangular-pattern problem. The results of these experiments will be discussed in the next section of this paper. From 20-40 trials were given daily.

In order to determine that the animals were responding to the visual stimuli placed in the doors of the apparatus and to no extraneous stimuli, the following controls were carried out during the course of the experiments.

1. The experimenter remained in a position at the front of the apparatus (where he could not be seen by the animal) until after the response had been made.

2. The animal was never placed in the apparatus by hand. The two boxes were used throughout the experiment.

3. The stimuli were presented in a predetermined chance order, and this order was changed in the final series of trials.

4. The route from the rear of the apparatus to the front of the discrimination chamber was constant throughout the experiment. The animal was always returned to the discrimination chamber via the right-hand side of the apparatus.

5. Food was equidistant from both stimuli at a point directly behind them.

6. After the animal had maintained an accuracy of 80% or

over in 30 trials, both of the doors were unlocked so that he could open either of them. This precaution was deemed necessary for the following reason: the locked door might observably be pressed more tightly against the aperture than the unlocked door which contained the correct stimulus. Although such a difference was not noticeable to me, it was considered advisable to control for this possibility.

7. New cards containing the same patterns as those used in the training series were substituted. This was to determine whether any differential markings on the cards, themselves, were being discriminated. (This was, of course, hardly necessary where the stimuli were switched from side to side of the apparatus by inverting the card.)

8. The light was moved from its original position to a point directly above the electric grid. This was to determine whether a slight shadow, thrown upon the stimuli by the animal's body when he was quite close to them, was influential. With the light at its new position, such a shadow was destroyed.

9. Finally, both of the patterns presented to the animal were negative, i.e., if the animal had been trained to respond negatively to a triangle with apex down, both stimuli were now identical triangles with their apices pointing downward. If the animal failed to respond, went into a position habit, or manifested a purely chance form of behavior, it would be apparent that the effective stimulus for the discrimination habit had been in the patterns rather than in extraneous cues. The animal, as a matter of fact, usually refused to make a response to either pattern under this condition. He ran excitedly back and forth before the patterns and then returned to the entrance box. If forced to respond (by means of a moving partition which pushed him toward the stimuli) he usually took a position habit, running always to the right or to the left. *None of the other controls was effective in disturbing the responses in any way.*

RESULTS

Black-white Discrimination. The results of the black-white discrimination in the apparatus already described are presented in Table 1. It will be seen that only 20 to 60 trials were necessary to reach an accuracy of 80% or over. The white rats seemed to discriminate much better than the hooded rats. This may be due to the fact that they were much slower than the other animals to cross the grid. They hesitated longer. (In a modification of the apparatus de-

TABLE 1
BLACK-WHITE DISCRIMINATION
Positive stimulus—white

Trials	Percentage correct in 20 trials Rat 7	Rat 8	Rat 9	Rat 10	Rat 11	Rat 12*	Rat 13*
20	45	35	45	75	40	70	50
40	50	70	60	70	50	80	80
60	80	75	80	80	70	100	70
80	95	90	95	90	90	100	90
100						100	100

*Rats 12 and 13 were white All other rats hooded

scribed above, in which a partition similar to that used in the Yerkes-Watson apparatus extended out from the center of the stimulus partition as far as the edge of the grid, 60 to 80 trials were necessary in order to master the discrimination. The lighting of the apparatus, however, was poor and the room was not darkened as was the room in which the above experiment was carried out Three hooded rats were used)

Discrimination of Triangles. The positive stimulus in this experiment was an equilateral triangle, with sides of 5 inches, presented on its base. The negative stimulus was an identical triangle presented on its apex The rats had already mastered the black-white discrimination Table 2 presents the results of this experiment Only 10 to 80 trials were necessary for mastery of the problem

In the modification of this apparatus mentioned above, in which a partition separating the two stimuli was present and in which the

TABLE 2
DISCRIMINATION OF EQUILATERAL TRIANGLES
Positive stimulus—triangle on its base Negative stimulus—triangle on its apex Triangles equal in area and brightness

Trials	Percentage correct in 20 trials Rat 4	Rat 5	Rat 6	Rat 9	Rat 10	Rat 12*	Rat 13*
20	65	65	80	65	50	50	60
40	85	80	95	80	60	65	70
60	100	80	100	95	80	70	90
80	90	90		90	90	80	95
100				100	95	90	100

*Rats 12 and 13 were white Other animals hooded

lighting conditions were much poorer, from 100 to 160 trials were necessary before the discrimination could be mastered. These animals, unlike those represented in the table above, had not been trained on the black-white discrimination before being placed on this problem After the animals had learned the discrimination of the triangle with apex up, I reversed the problem, i e., I required the animals to react positively to the stimulus which had previously been negative. They refused to discriminate at first. By means of a moving partition, I forced them to approach the stimuli. Even though a strong electric shock was administered every time the animal entered the short alley containing the stimulus which had been positive in the previous experiment, not one of the animals made a response of better than 30% in 20 trials until 80 trials had been given. They persisted in approaching the triangle toward which they had formerly been conditioned. One animal got the first 25 trials in succession wrong even though he received a strong shock at each trial The training was continued until the animals had learned to go to the *new* positive stimulus with an accuracy of from 80 to 100% in 30 trials. This took from 100 to 160 trials This control was carried out merely to test the strength of the original conditioning to the triangle with apex up.

Discrimination of Patterns Containing Horizontal and Vertical Stripes. These patterns gave results similar to those obtained with the triangular patterns. The vertical stripes were positive for some animals and the horizontal stripes were positive for others The stripes were 1 cm. in width There seemed to be no difference in the difficulty of the two patterns The data are presented in Table 3. The apparatus was as described in the second part of this paper.

Circle-vs-Square Discrimination. This is the only problem in

TABLE 3

DISCRIMINATION OF HORIZONTAL VS. VERTICAL STRIPES

Black and white stripes 1 cm in width

Trials	Percentage correct in 20 trials								
	Rat 2	Rat 3	Rat 4	Rat 5	Rat 6	Rat 7	Rat 8	Rat 12*	Rat 13*
20	55	55	40	60	50	50	60	45	40
40	60	80	60	55	75	50	80	40	80
60	80	85	60	60	65	80	80	50	80
80	95	100	75	80	95	85	75	70	100
100			85	85	90	95	90	100	100

*Rats 12 and 13 were white Other rats hooded

which negative results were obtained. One of the animals, for whom the square was positive stimulus, showed some evidence of having mastered the problem between the 60th and 80th trials, when he made a record of 80% correct responses He went into a position habit, however, and did not recover the discrimination in a further 150 trials. None of the other animals, for two of which the circle was positive stimulus, showed any evidence that it would ever master the discrimination. The rats soon acquired position habits from which I could not entirely break them The results of this experiment are summarized in Table 4. All of these rats had learned the

TABLE 4

CIRCLE VS SQUARE

Both stimuli equal in area and brightness

Trials	Percentage correct in 50 trials Rat 2	Rat 3	Rat 6	Rat 7
50	56	60	60	54
100	70	60	46	50
150	58	50	54	50
200	64	52	56	50
250	54	54	58	

previous problem and one of them had learned the discrimination of equilateral triangles The experimental conditions were the same for all three experiments. The negative results surprised me, since Lashley has obtained circle-square discriminations in his apparatus. This difference in results may be due to some difference in technique, or it may be due to individual differences in the animals.

DISCUSSION

Except for the fact that the rats used in these experiments did not go *without training* to a white stimulus, and that they did not learn the circle-square discrimination, my results are comparable with those obtained on Lashley's apparatus

From observation of the behavior of rats in the Yerkes-Watson apparatus, Lashley's apparatus, and the present apparatus, I am forced to the conclusion that the positive results obtained with the two last-mentioned apparatuses, as against the negative results on the Yerkes-Watson apparatus, are due to the fact that the animal, by the nature of the apparatuses themselves, is *forced to respond to the stim-*

uli to be discriminated. He either jumps against them or runs against them In the Yerkes-Watson apparatus the stimuli are not necessarily associated with food, and the animal may never respond to them. Why, then, it may be asked, does the rat learn brightness discrimination in the Yerkes-Watson apparatus while he is unable in the same apparatus to discriminate patterns of equal area and brightness Probably because, with brightness discrimination, there is a differential reflection of light on the floor and sides of the alleys through which the animal passes which, unlike patterns of equal area and brightness, is associated with the animal's pathway to the food-entrance box, or with the shock which the animal may receive after an incorrect response Other possibilities of explaining the discrepancy between Lashley's and the present apparatus and the Yerkes-Watson apparatus can be readily set aside. The time which, in the Yerkes-Watson apparatus elapses before the animal can be fed after a correct response is, as I have previously pointed out (9), not sufficient to prevent the animal from learning the discrimination. Clements (1), with a delayed feeding of 30 seconds on a simple maze problem, found that this delayed feeding was not sufficient greatly to effect the ability of the rats to learn the problem The enforced pause, characteristic of Lashley's apparatus and not present in my apparatus, cannot be invoked to explain why rats learn pattern discriminations in Lashley's apparatus and do not learn them in the Yerkes-Watson apparatus The type of punishment characteristic of Lashley's technique cannot, as I have already pointed out, explain the discrepancy existing between the results obtained in his apparatus and those obtained in the Yerkes-Watson apparatus.

Conclusion

An apparatus has been described which yields results on Pattern vision in hooded and white rats comparable with results obtained by means of Lashley's technique.[4] The technique described in this

[4]Since the above was written, Mr Joseph Steinert of the University of Pittsburgh has repeated the experiment involving triangles His animals learned the discrimination within 70 trials Further controls, however, showed that the animals could not discriminate outlines of the triangles If a rectangle with a base line equal to that of the triangles, and of the same area and brightness, was substituted for the positive triangle, the discrimination of the animals was not disturbed When a diamond-shaped form was presented with the rectangle, the animals still discriminated the rectangle These experiments show that the animals are responding to low versus high brightness masses rather than to triangles as such I found this likewise to be true in my repetition (10) of Lashley's experiment.

paper requires less preliminary training than Lashley's and is adapted to a wider variety of animal forms It is suggested that the discrepancy between Lashley's results and those obtained by means of the Yerkes-Watson apparatus is due to the fact that Lashley's technique (as well as that of the present problem) *guarantees* that the animal shall respond directly to the stimuli to be discriminated, whereas, in the Yerkes-Watson apparatus, the responses of the animal are *not* necessarily associated with the stimuli to be discriminated.

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UN APPAREIL POUR MESURER LA DISCRIMINATION VISUELLE CHEZ LES ANIMAUX

(Résumé)

On décrit un appareil qui donne des résultats sur la vision des formes chez les rats blancs et encapuchonnés comparables aux résultats obtenus au moyen de la technique de Lashley. Ils ont appris en de 20 à 60 épreuves la discrimination de triangle différant à l'égard de la position de leurs apex et celle de formes contenant des lignes horizontales et verticales. La technique décrite dans cet article exige moins d'entraînement préliminaire que celle de Lashley et s'adapte à une plus grande variété d'animaux. On suggère que la différence entre les résultats de Lashley et ceux obtenus au moyen de l'appareil Yerkes-Watson est due au fait que la technique de Lashley (ainsi que celle de ce problème-ci) *garantit* que l'animal répond *directement* aux stimuli à discriminer tandis que dans l'appareil Yerkes-Watson les réponses de l'animal *ne sont pas* nécessairement associées aux stimuli à discriminer.

MUNN

EIN APPARAT ZUR UNTERSUCHUNG VISUELLER UNTERSCHEIDUNG ('VISUAL DISCRIMINATION') BEI TIEREN

(Referat)

Es wird ein Apparat beschrieben, welches über Gestaltvision ('pattern vision') bei weissen und kapuzierten ('hooded') Ratten Resultate liefert, die sich mit Resultaten durch Lashley's Verfahren erzielt vergleichen lassen. Die Unterscheiding zwischen Dreiecken die in Bezug auf die Lage ihrer Spitzen verschieden waren wurde in 20 bis 60 Proben bemeistert. Das Verfahren, welches in dieser Arbeit geschildert wird, verlangt weniger vorbereitende Dressierung wie Lashley's und ist einer grosseren Mannigfaltigkeit von Tierformen angepasst. Es wird angedeutet, dass der Unterschied zwischen Lashley's Resultaten und den mit dem Yerkes-Watson-schen Apparat erzielten darin liegt, dass Lashley's Verfahren, (wie auch das Verfahren im jetzigen Problem), *versichert*, dass das Tier direkt auf die Reize reagieren wird, die zu Unterscheiden sind, wahrend mit dem Yerkes-Watsonchen Apparat die Reaktionen des Tieres nicht notwendigerweise mit den zu unterscheidenden Reizen verbunden sind.

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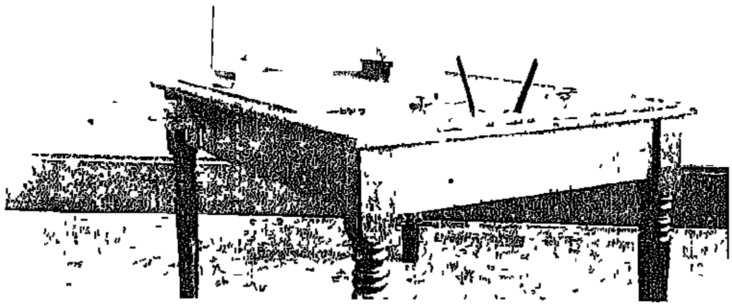
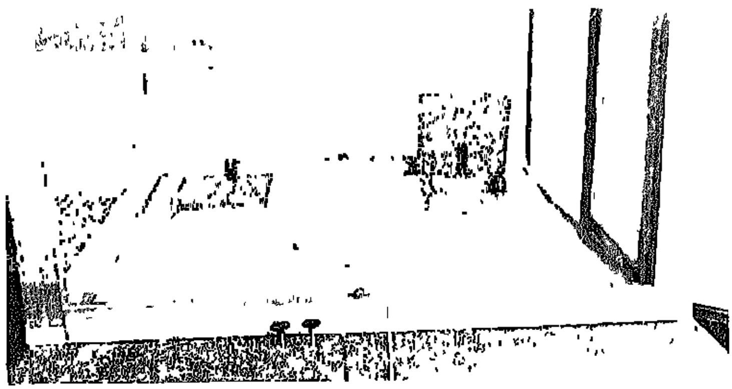
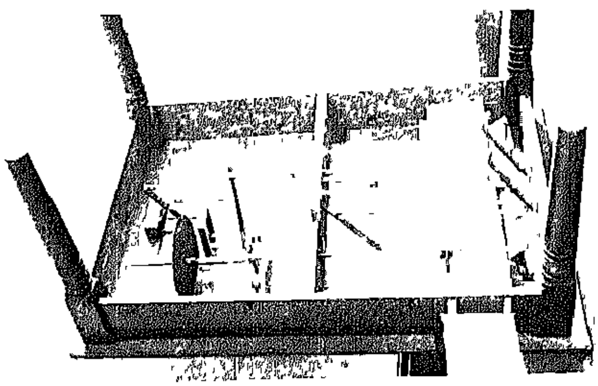






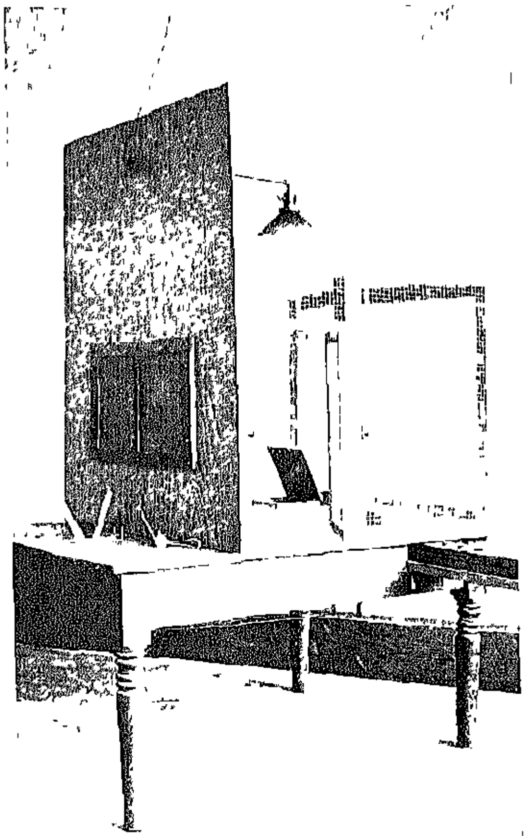


FIGURE 1

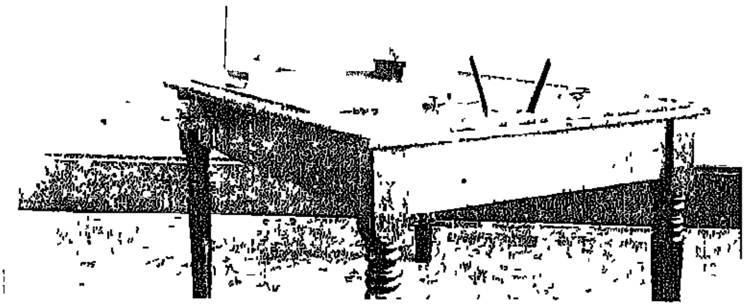
PHOTOGRAPHS OF THE ALTERNATION BOX-APPARATUS

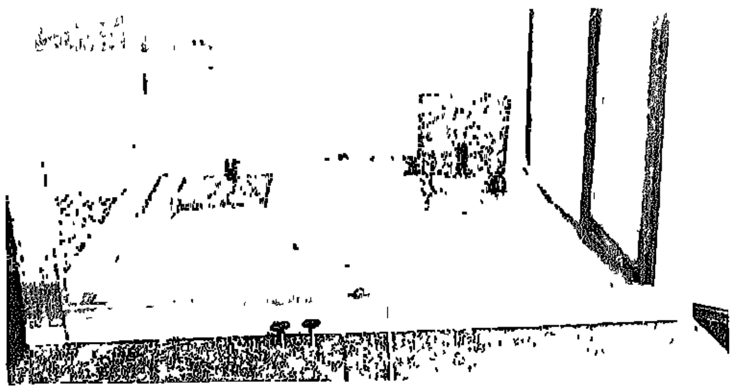
In the picture above the open L box may be seen through the cage door. The one-way vision screen, the restraining rope, the lighting arrangements, and part of the food carriage and its platform are also shown.

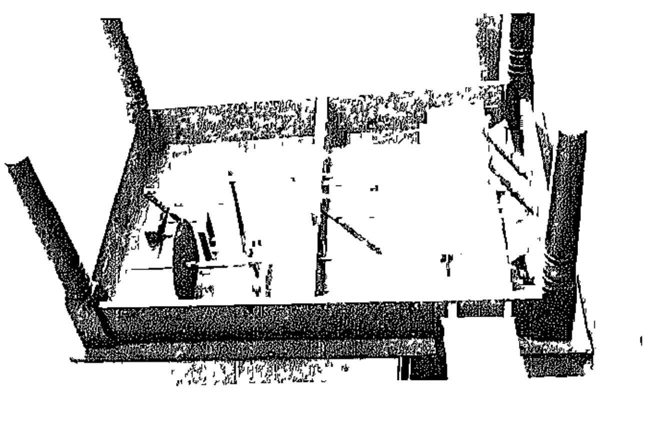
In the top picture on the next page the cage and screen board have been removed from the alternation box-apparatus. The notched disc for moving the food carriage, the box lock keys, and the levers that control the box lids may be seen on the near (experimenter's) end of the table. The food carriage is in the position which it occupied at the beginning of a trial.

The middle picture on the next page gives the experimenter's view of the interior of the alternation box-apparatus. The screen panel and its one way vision window have been removed. The sawdust floor covering and the closed cage door may be noted.

The lower picture on the next page shows the mechanical parts of the alternation box-apparatus underneath the table. The experimenter's end of the table is on the reader's left. There the lid control levers, the notched disc, and the box key thrusts may be seen. On the right are the lid balancing mechanisms and the lid locks.







maze The results of the experiment will show convincingly that the alternation box-apparatus may be placed with the temporal maze as a valid method of testing for ability to perform double alternation and thus for demonstrating the presence of symbolic processes

The monkey has already demonstrated his ability to master the double alternation problem of four responses It was decided in this experiment, therefore, to use a longer series of responses during training than had been used in the temporal maze problem (1) The present paper seeks to answer experimentally the following questions

1 Can the monkey learn the double alternation of a series of eight responses, *R R L L R R L L*?

2 Following learning, can he extend this double alternation of responses to series of greater length than eight responses?

3 Is the double alternation of responses by the monkey under these experimental conditions independent of cues from the experimenter and from the apparatus itself?

Apparatus

Figure 1 shows photographs of the alternation box-apparatus used in this experiment. This new apparatus is peculiarly suited to the double alternation problem because the experimenter is able to determine the order in which the boxes may be opened, and to introduce quickly new bits of food into the boxes The lids of the boxes project an inch at the front in order to enable the monkeys to open them readily Within each box all of the sides are bevelled to a center hole 2″ square At a depth of 2½″ from the top of the boxes, food is introduced beneath the boxes by means of a trough-like carriage which contains 16 compartments, each 2″ square and 1″ deep Thus the monkey has to reach only a short distance beneath the level of the table top to secure the food The experimenter controls the movement of the food carriage by means of a notched disc and a pinion and gear system Food can be placed in the compartments of the food carriage with ease since the platform upon which the carriage rolls extends well out to the side of the apparatus The lids of the boxes are automatically locked shut, and the experimenter determines by depressing one of two keys, which box may be opened on a given response. Furthermore, the movement of the lids may be controlled from the experimenter's end of the table by a series of noiseless levers which are so balanced that the lids fall shut when not held

open If the subject holds the box lids open they may be closed by the experimenter. The apparatus operated so simply that no difficulty was encountered in making the necessary observations of behavior throughout the trials.

The cage within which the boxes are located is made of ¼" mesh wire mounted on a wooden frame, which is held on the table top by two bolts. The cage may be readily removed in order to clean the apparatus The side of the cage on the experimenter's end of the table is made of 3-ply wood panelling and extends 18" above the top of the cage. The single light used to illuminate the apparatus during experimental work is supported on this panel The screen window in the panel permits only one-way vision, and thus enables the experimenter to see the monkeys at work without their being able to see him The possibility of only one-way vision was tested by a number of persons, and none of them could see through the screen from the cage side, no matter how close they placed their eyes to the screen.

The monkeys were admitted to the cage through a door (12" x 22") They were held at the front of the apparatus before starting work, and drawn back to this position after finishing each trial by means of a small rope passing through the center of the cage wall just underneath the screen window

Method

1 *Subjects* Four rhesus monkeys were used in the present study One of these was Bones, who had mastered the double alternation problem in the temporal maze. The other three monkeys were new members of the Clark colony. They were a year younger than Bones, and were secured from the Benson Animal Farm soon after their arrival in this country. One was a female named Daisy, and two were males named Goofy and Squeak. These animals I tamed completely during the four and one-half months between their arrival and the time they started work in the double alternation box-apparatus They became thoroughly accustomed to the laboratory and to me. They could be handled with ease and, when loose, would play about their living quarters and the experimental room without exhibiting timidity or fear

The animals were fed daily inside the apparatus cage on top of a table for one month. There were no boxes on this table During this time the animals became accustomed to the cage and table situ-

ation. At first they climbed all over the walls of the cage, and bit and shook at the walls and doors, but such behavior disappeared within a week During the last two weeks before experimental work was undertaken the construction of the apparatus interfered with this daily feeding within the cage, but the animals showed no signs of disturbance upon being introduced later into the apparatus during their preliminary trials

2. *Procedure* Each animal was given a preliminary trial daily for five days The purpose of these preliminary trials was to teach the subjects to open the boxes and secure food. The procedure was adapted to this end, and will be described in connection with results Regular trials were given once a day for five days, and thereafter twice a day (7 A.M and 7 P.M). The procedure during a regular trial was as follows. With the key for the box on the right (R) depressed, I released the rope which held the subject at the front of the cage The subject was then free to go to the boxes and attempt to open either of them If he responded to the R, he could open the box and get a grape. If his first response was to the L, the box would not open, and he would have to open the R box to get his first grape. The taking of a grape brought to an end the first response, and marked the beginning of the second Since there were eight responses in the order R R L L R R L L in each trial, the subject secured eight grapes per trial He was credited with a correct response each time he opened the unlocked box without first having attempted to open the other box After the subject had taken his eighth grape he was drawn to the front of the cage by means of a rope Time for each trial was counted from the moment that the animal was released until the eighth grape was secured. Complete records were kept of each response, any extra attempts to open either box, time of the trial, time of other events such as pauses, etc., and any other behavior which appeared to be significant The criterion of learning in this experiment was the same as that in the other experiments of this series, namely, three correct trials in succession.

This procedure in the double alternation box-apparatus is identical in principle with that employed in the double alternation temporal maze. In the latter the subject is required to go around the correct side of the maze following each response whether the response was correct or not. Furthermore, in the case of the monkeys, reward was given in the temporal maze each time the animal came to the

front of that apparatus, irrespective of the correctness of his responses. The plan described above for the double alternation box-apparatus duplicates these conditions in that food is secured following each completed response, and, under the conditions of the problem, a new response cannot begin until food has been taken from the correct box.

The monkeys were run in the same order each day They were taken one at a time into the experimental room and introduced into the cage The rope was snapped to their collar chain and they were held at the front of the apparatus to prevent any uncontrolled practice in opening the boxes Following each trial the animal was released from the cage and allowed to play about the room while grapes were placed in the food carriage in preparation for the next subject He was then returned to his living quarters and fed Throughout the experiment the animals were very tame As the experiment proceeded, they became so accustomed to working in the same order every day that I usually found each one waiting at the living cage door when I came to get him If not, I needed only to open the door and call to or point at the monkey I wanted, and he would come to me at once. Bones would go before me into the experimental room, open the door of the apparatus cage, and enter it alone Here he would take a position facing the door and wait until the rope was snapped to his collar chain Then he would move over to the center of the apparatus close to the front wall without waiting for me to draw him to that position with the rope. Daisy also learned to enter the apparatus alone The other monkeys were usually held by the hand, and they never attempted to break away. I emphasize the tameness of the animals, since I believe that it contributed toward the excellent results which were secured in this experiment

During the experiment two cages were used as living quarters for the animals This fact enabled me to solve partially the problem of maintaining the necessary degree of hunger among the monkeys Had they all been fed at once each would have secured a different amount of food. Among this group of monkeys each animal either dominates or is dominated by each other animal. In our colony the monkeys took the order Bones, Sis, Squeak, Goofy, and Daisy. Each animal chased away from available food all those following it in this list Each day I fed the monkeys in a new cage By working with them in just the reverse of the above order, it was possible for the weaker

monkeys to get enough food before the strongest monkeys had finished the experiment Even under these conditions the monkeys were occasionally overfed and refused to work during a set of trials I followed the general rule that, if an animal completed four responses, he was left in the apparatus until all of the responses for the trial were completed.

Results

1. *Learning*

a. Habituation. So far as I know, none of the monkeys except Bones had had any experience opening boxes before their first preliminary trials in the double alternation box-apparatus Bones's experience had consisted in a few occasions during the spring of 1929 when I put a box in his living cage to see if he would open it readily (It was at that time that the first plans for the present experiment and the alternation box-apparatus were being made) When the monkeys were introduced into the apparatus on their first preliminary trial, the lids of both boxes were open and each box contained food Goofy alone reached into a box and touched food, but he did not take it Daisy and Squeak looked into each box Bones tried to shake his way out of the cage, and never approached the boxes. Each animal was removed from the apparatus in ten minutes. On the second day both boxes were again open and contained food After a subject had taken food from the box the lid was allowed to fall shut. Only Goofy opened a box by himself and took more food. On the other preliminary trials the boxes were both unlocked, but closed. Occasionally I would open a box slightly to encourage a subject to open it. On each of these days all of the monkeys except Bones took eight grapes each. Bones took food only on his last preliminary trial During the first regular trials the subjects would try to open the incorrect box, on a given response, a number of times before opening the correct one This behavior corresponds to the extraneous moves made by subjects in their early trials in the temporal maze. On one occasion Squeak attempted to open the *R* box on his fourth response ten times in rapid succession before turning to the *L* box. Within six or seven trials each animal learned to turn at once to the other box whenever he found that one was locked. Goofy was the first subject to form this habit of regular work. After his fourth trial he made no extraneous moves.

b. Simple alternation behavior Following habituation, all of

the subjects responded typically in the order *R L L R R L L R* (That this is not double alternation behavior will become evident in the analysis of this series of responses which follows.) It seemed that the more rapidly a subject worked the more quickly his responses fell into this order The phenomenon appeared with Bones only during the first two-tenths of learning With the other subjects it was more or less in evidence throughout the learning period. This was especially true of Goofy, who, *during the middle half of his* learning, made this type of response trial after trial. It will be noted that, in the series of responses *R L L R R L L R*, responses 1, 3, 5, and 7 which are *correct* are followed by alternation, in that responses 2, 4, 6, and 8 are opposite to them This has been called "alternation after success" by Hunter (3, p 216, 4, p 1, 6, p. 531) In the first paper of this series this interpretation of such a series of responses has been questioned in favor of an explanation in terms of simple alternation (1, p. 62) In the temporal maze this simple alternation was one of trips from the point *X*, and it is necessary to recognize a difference in the various trips from this point Some of them *were preceded by a trip up the center alley of the maze, and others* followed a response to the incorrect side and retracing to the point x. In the temporal maze it is true that each successful trip from the point x *following a trip up the center alley* was followed on the next regular response by alternation

The distinction between the various reactions from the point x in the temporal maze does not appear in the same light in the double alternation box-apparatus Here there is no center alley The subject sits before or between the boxes and attempts to open one box or the other. We have been speaking of "response" in this experiment in terms of the first box attempted following release at the beginning of a trial and the taking of each grape thereafter. However, if the incorrect box is attempted on a response the animal quickly learns to attempt the other box In fact, he typically tries first one box and then the other in rapid succession, taking grapes from those boxes which will open. Such behavior gives the series of responses *R L L R R L L R* In view of the fact that the animal tries first one box and then the other as rapidly as possible, I believe that this type of behavior should be described as a *simple alternation* of attempts rather than as "alternation after success" In the following record for such a trial the first letter after the number of each response indicates the response with which the

Number of response	Subjects attempts to open	
1	*R*	(correct)
2	*L R*	(error)
3	*L*	(correct)
4	*R L*	(error)
5	*R*	(correct)
6	*L R*	(error)
7	*L*	(correct)
8	*R L*	(error)

subject is credited. The second letter in the case of responses 2, 4, 6, and 8 indicates that the animal turned to the unlocked box and opened it. This record is typical of the records kept throughout the experiment in that every attempt to open a box was recorded. It should be understood that the record on each line ends with the taking of a grape In this sample record it may be seen that the animal alternated not only with success, but also with failure, if one is describing the actual box opening behavior of the subject. His attempts were in the order ***R*** *L* *R* ***L*** *R* *L* ***R*** *L* *R* ***L*** *R* *L* The attempts which have been boldfaced are the ones which, under the conditions of the problem, are credited to the animal as his responses for the trial As has been stated above, this is the typical series of responses immediately following habituation and in this series only 50% of the responses are correct

c. Quantitative data on learning All the monkeys learned the series of eight responses *R R L L R R L L* in the alternation box-apparatus Table 1 shows for each subject the number of trials before the first correct trial, the number of trials before three successive correct trials (criterion of learning), the number of correct

TABLE 1
DATA ON TRIALS DURING LEARNING

Subject	Trials before first correct trial	Trials before mastery	Trials correct prior to mastery	Trials in which 7 responses were correct
Daisy	82	134	9	41
Goofy	50	72	1	14
Squeak	50	102	4	11
Bones	16	114	7	32

TABLE 2
NUMBER OF CORRECT RESPONSES IN EACH SUCCESSIVE GROUP OF FIVE TRIALS PRIOR TO MASTERY
(40 responses in each group)

Daisy	Goofy	Squeak	Bones
18	21	21	23
17	20	20	24
18	25	23	23
18	19	22	24
26	20	28	33
26	23	25	29
27	24	23	28
30	28	25	29
28	30	27	28
31	31	27	26
28	30	30	26
28	30	29	20
30	31	22	29
29	29	23	31
30	9 in 16	25	29
31		25	27
33		24	31
34		24	31
31		33	36
30		29	35
27		12 in 16	36
37			32
34			27 in 32
35			
36			
33			
30 in 32			

trials during learning, and the number of trials in which 7 of the 8 responses were correct during learning. Goofy, who had adapted himself to the experimental situation before the other monkeys, learned the problem most quickly Daisy during the last 30 trials of learning had 6 trials correct, and in 24 trials she made an error on her second response. (On 4 of these 24 trials she also made one other error) This persistent error on Daisy's second response was the result of the way she took her position in the apparatus When I released her at the beginning of the trial she would step out to the boxes and open the *R* box first. As she assumed a sitting position between the two boxes (her working position), she turned toward the left and usually attempted to open the *L* box on her second response All the other monkeys, in assuming the working position, turned toward the right and were facing the *R* box for their second

TABLE 3
ERROR AND TIME RECORDS FOR DIFFERENT SUBJECTS

	Daisy	Goofy	Squeak	Bones
Trials to learn	134	72	102	114
Total errors during learning	294	206	297	240
Average errors per trial	2 2	2 9	2 9	2 1
Total time for learning	5820	3167	3923	6694
Average time of 10 correct successive trials	11 9	14 6	17 1	14 8
Time of best single trial	10 2	9 0	10 4	11 0

response Daisy finally solved the situation, but not by learning to turn to the right following response 1 Instead, she learned to keep her hold on the lid of the *R* box and, still turning to the left, jumped over *the R box* This odd habit persisted until, after *9* or *10* successive correct trials, Sis changed to a right turn following her first response. A discussion of the way in which all of the subjects eliminated their errors and learned the double alternation box problem will be presented later in connection with the difficulty of the various responses (see page 371).

Table 2 records for each subject the number of correct responses in each successive group of five trials prior to mastery. The extended period during which Daisy made only one error is evident in this table.

The upper part of Table 3 shows the number of trials for learning, the total errors, and the average errors per trial for each subject. It will be noted that Goofy and Squeak learned the problem in fewer trials than did Daisy and Bones, but their average errors are higher than those of the other subjects The average number of errors per trial for the group is 2.5 This figure is similar to the average number of errors per trial of 2 6 made by human adults (2, Table 3) in the 8-response problem in the temporal maze. However, the monkeys took an average of 105 5 trials to learn the 8-response problem, while the human adults learned a similar problem in the temporal maze in an average of 6 2 trials. The lower half of Table 3 presents the total time consumed during learning by each of the subjects, together with other time data which indicates the speed at which the subjects were working after mastery. In comparing the total time for the different subjects the number of trials must be borne in mind.

TABLE 4
AVERAGE TIME AND ERROR RECORDS FOR EACH TENTH OF LEARNING AND FOR TWO COMPARABLE PERIODS THEREAFTER

Tenth of learning	Time in seconds	Percentage of wrong responses
1	1727	48.2
2	713	37.8
3	430	34.1
4	325	35.6
5	306	33.9
6	310	27.4
7	301	28.9
8	314	26.8
9	268	20.8
10	228	21.0
Following mastery		
1	163	2.4
2	170	1.2

Squeak proved to be the slowest subject during the last part of the experiment, as the average time for his 10 successive correct trials shows. However, he took less time during the early trials of the experiment than did the other monkeys. Bones was the slowest monkey of the group, and Goofy and Daisy usually worked the most rapidly. It should be clear from these time records that a faulty or cumbersome apparatus would have made successful work almost impossible.

Table 4 presents the average time and error records of the group for each tenth of learning and for two comparable periods thereafter. Time records are stated in terms of average total seconds per tenth. Error records are in terms of the percentage of wrong responses for each tenth of learning. These data are plotted in Figure 2. The line for average time is similar to time curves usually found for ordinary habit formation. The line for errors drops toward the base line suddenly and continues close to that level after the point of learning.

d. Relative difficulty of responses. In the two preceding papers (1, 2), I have analyzed the data for errors in order to determine which responses in the series of responses constituting a trial were learned most and least easily by the different subjects. This was done in the hope that additional light might be thrown on the nature of double alternation behavior. The analyses led to the dis-

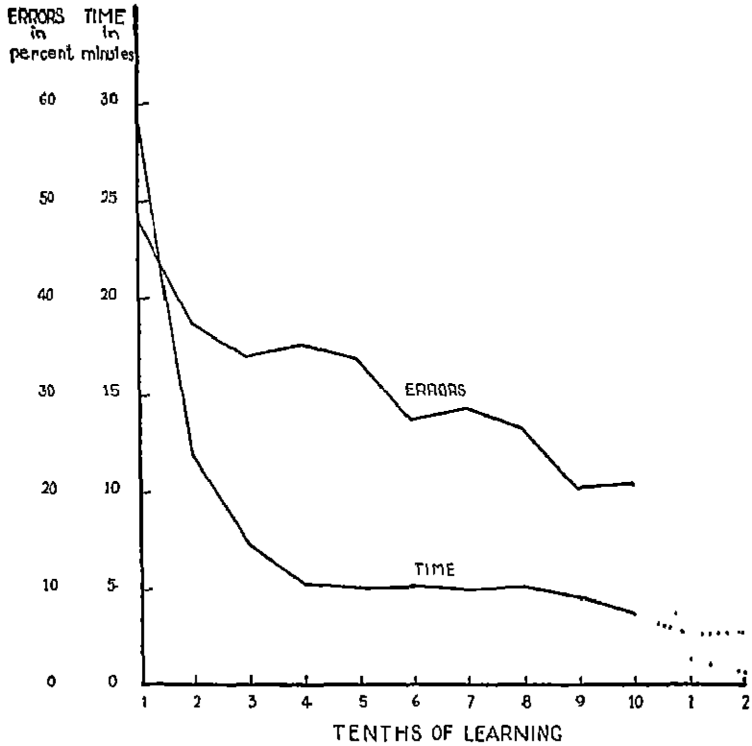


FIGURE 2
AVERAGE TIME AND ERRORS FOR EACH TENTH OF LEARNING AND FOR TWO COMPARABLE PERIODS THEREAFTER

covery of some points of similarity and some points of difference between the behavior of different groups of subjects Let us now consider the data of the present experiment from the same point of view.

Table 5 and Figure 3 show the relative difficulty of each of the eight responses during learning for each subject. The data are presented in terms of the percentage of trials in which errors were made by each subject on each different response Here a striking fact appears. The records for Bones show a quite different order of difficulty among the responses than do those for the other three subjects. Daisy, Goofy, and Squeak found responses 1, 3, 5, and 7

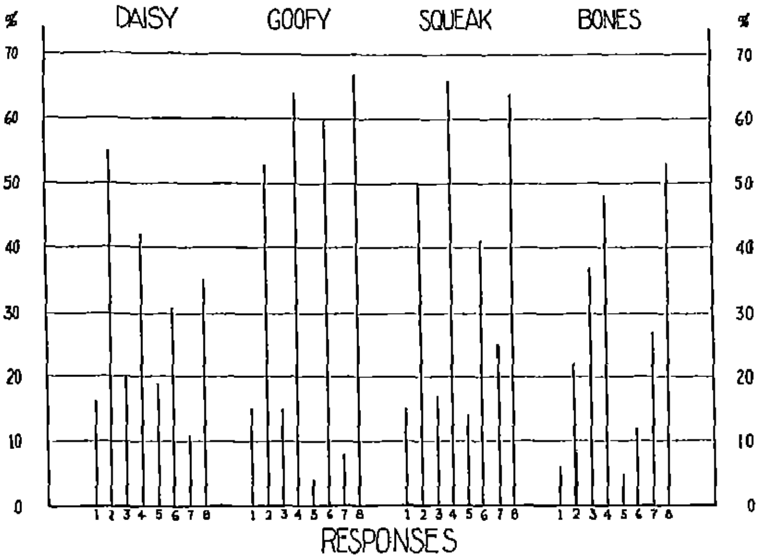


FIGURE 3

Percentage of Trials in Which Errors Were Made by Each Subject on Each Different Response During Learning

Note that for three of the subjects the even-numbered responses were most difficult (most errors were made on them) but that for the fourth subject, Bones, the order of difficulty was 4-3-2-1 and 8-7-6-5. See the discussion in the text

easy, and responses 2, 4, 6, and 8 difficult. The differences in percentage of errors between the responses in each of these groups are slight and the differences between responses of different groups are large. This is the same type of result secured for both monkeys and human subjects in the temporal maze, in which the odd-numbered responses were performed correctly most of the time, and the majority of errors occurred among the even-numbered responses As has been explained above, this results from a tendency toward simple alternation (see page 367). It will be noted that Goofy, who most typically performed his responses in the order *R L L R R L L R* during learning, has records which show the greatest difference for errors made on odd- and even-numbered responses In general, the order of difficulty among the first four and last four responses for these three subjects was, from most to least difficult, 4, 2, 3, 1, and 8, 6, 7, 5

TABLE 5

PERCENTAGE OF TRIALS IN WHICH ERRORS WERE MADE BY EACH SUBJECT ON EACH DIFFERENT RESPONSE DURING LEARNING

Response	Daisy	Goofy	Squeak	Bones
1	16	15	15	6
2	55	53	50	22
3	20	15	17	37
4	42	64	66	48
5	9	4	14	5
6	31	60	41	12
7	11	8	25	27
8	35	67	64	53

Bones's records show a different order of difficulty With him the order of responses from most to least difficult reads, 4, 3, 2, 1, and 8, 7, 6, 5 Only during the first two-tenths of learning did the even-numbered responses prove to be more difficult than the odd-numbered responses for this subject This means that instead of responding typically in simple alternation throughout learning, Bones tended to make a double alternation of responses He responded *R R* on responses 1 and 2, and on 5 and 6 Then he learned to respond *L* on responses 3 and 7, and, finally, to respond *L* on responses 4 and 8 As this statement implies, the figures presented in Table 5 not only indicate the responses on which most errors occurred, but also (in the opposite order) the responses which were fixed correctly most early during the learning process. With all subjects but Bones the odd-numbered responses were fixed correctly first, then the even-numbered responses were fixed, although a large percentage of errors on responses 4 and 8 usually persisted up to the point of learning.

The order of fixation of correct responses for Bones is most unusual for the double alternation problem, and it is different from the order for any other subject tested in the present series of experiments. It also differs from the situation in this respect with rats and raccoons where Hunter (5, 6) found that the typical series of responses for these animals preceding learning was *R L L L* and in this series the second response gave most difficulty and was the last to be learned In making these comparisons it must be recognized that some subjects performed four responses and others performed eight responses per trial, but, in every case, except this one for Bones, the odd-numbered responses, proved easier and were fixed

correctly earlier during learning than the even-numbered responses. With Bones, responses 1 and 5 were fixed correctly during the first tenth of learning Responses 1 and 2 were regularly *R R* after the 12th trial, and responses 5 and 6 were regularly *R R* after the 19th trial Response 7 appeared regularly as *L* after the 64th trial, and response 3 was regularly *L* after the 82nd trial Responses 4 and 8 remained unfixed until the point of learning (115th trial).

What the explanation of this difference in the behavior of Bones and the other subjects is I do not know. It differs markedly from his own behavior in learning the double alternation temporal maze. In that problem Bones succeeded in making the second response correctly in only 7% of his trials preceding learning. It is possible that the double alternation of responses in the case of this subject carried over from his mastery of the temporal maze, although an interval of over six months had elapsed between his 20 successive correct trials in the double alternation temporal maze and the beginning of the present experiment Bones was the only subject in the present problem who had had any previous training in the double alternation of responses, and he alone demonstrated a typical double alternation of responses from an early point in the present experiment.

2. *Extension of the Double Alternation of Responses* After the animals had learned the double alternation of 8 responses, they were tested on longer series Before these tests were made, however, each subject was trained until he could perform 10 correct trials, of 8 responses each, in succession. Goofy and Bones did this immediately following learning Daisy completed her tenth correct successive trial 20 trials after learning. Squeak took 23 trials before he had performed 10 successive correct trials. During the 20 trials Daisy made only 1 error on each of 3 trials, and Squeak during his 23 trials made 1 error on 6 occasions. At the time the subjects were tested on the extended series of responses the total number of correct trials of 8 responses each for the different subjects was as follows Goofy, 11; Squeak, 21; Bones, 17; Daisy, 26. During these trials and in many others in which 6 or 7 responses had been correct, the subjects had often attempted a ninth response while I was pulling them away from the boxes. Invariably this ninth response was made toward the *R* (correct) box This evidence gave promise that the monkeys would succeed in the double alternation of responses in a series longer than 8 responses Such proved to be the case

Goofy was the first animal tried on a series of 12 responses. After the eighth response he hesitated very slightly and then slowly responded twice more to the *R* (correct). Following this, he came to the door of the apparatus of his own accord I took him out at once. On the next trial he responded 12 times correctly without hesitation. On the next two trials Goofy performed series of 14 and 16 responses, respectively, without error This was the greatest number of responses it was possible to complete with the present apparatus, since there were only 16 food compartments in the food carriage. The other monkeys also succeeded in the extension of double alternation to series longer than those used during training, performing correctly during four successive trials series of 12, 12, 14, and 16 responses With the exception of Goofy's first extended trial, no monkey even hesitated on the longer series, and no subject made errors on these extended trials.

I had found nothing in my work with the monkeys in the temporal maze (1) to indicate that they could not extend the double alternation of responses beyond the length of the training series. The only evidence relevant to this problem consisted in one trial in which Bones opened the left front door of the temporal maze and went up the center alley, following his fourth trip to the front of the apparatus. On this occasion he made his fifth response to the *R* (correct). That evidence, however, could hardly be taken as a demonstration of the extension of the double alternation of responses. The striking performance of the monkeys in the present experiment is doubtless due to the fact that the alternation box-apparatus is better suited for work with monkeys than is the temporal maze.

In successfully extending the double alternation of responses beyond the length of the training series, the monkeys demonstrated ability in the double alternation problem far superior to that found for rats or raccoons by Hunter. The rat cannot learn the series *R R L L* in the temporal maze (4, 6), and, even when the rat is able to perform the series of four responses correctly after a special type of training, it responds *R R L L L L L* when tested upon series of eight responses (7) The raccoon can learn only the simplest form of double alternation, the four response series *R R L L*, and when tested upon longer series also responds *R R L L L L L* (5) Human subjects, on the other hand, can master the double alternation problem and extend the double alternation of responses beyond the length of the training series with facility (2). Thus we

find for the ability to *extend* the double alternation of responses a genetic series similar to that found for ability to solve the double alternation problem and for ability to perform the delayed reaction This fact suggests that there may be required in the extension of series some symbolic process or some central neural process similar to that assumed for mastery of double alternation and for successful performance of the delayed reaction. None of these phenomena can be explained upon a stimulus-response chain-reflex basis.

Additional evidence that ability to extend the double alternation of responses beyond the length of the training series is dependent upon symbolic processes is afforded by the behavior of human subjects in the double alternation temporal maze. Solution of the problem of double alternation with human subjects always is accompanied by the verbal formulation in the general form, "two to the right, two to the left, etc" (5, p. 378; 2, p. 207) These verbal responses are the symbolic processes which supplement the non-differential stimuli encountered while running the temporal maze, and make possible the double alternation of responses In trials with extended series, the subject typically makes the number of responses contained in the regular learning trials and then hesitates. Since he is not released from the maze at this time, he is confronted by a general form, "I'll follow the same plan [two-two] in these additional responses ("choices" and trips through the maze) From the verbal behavior of subjects at such times and from their verbal reports thereafter it is clear that the subjects are enabled to perform the double alternation of responses throughout these extended series by means of their verbal formulation, "two to the right, two to the left," together with a self-administered instruction stimulus of the general form, "I'll follow the same plan [two-two] in these additional choices"

This aspect of double alternation behavior may be compared with certain of the behavior tests used in the Army Intelligence Examinations. The following is a partial representation of the number series completion test from Form 5 of Group Examination Alpha (9, p. 225)

TEST 6

	2	4	6	8	10	12	14	16
SAMPLES	9	8	7	6	5	1	3	2
	2	2	3	3	[illegible]	[illegible]	5	5
	1	7	2	7	[illegible]	7	4	7

Look at each row of numbers below, and on the two dotted lines write the two numbers that should come next

3	4	5	6	7	8		
10	15	20	25	30	35	40	45
8	7	6	5	4	3		
3	6	9	12	15	18		
5	9	13	17	21	25	..	
8	1	6	1	4	1	..	..

In these tests the task of the subject is twofold. First, he must go over each series of numbers until he can induce a formula for it. This behavior coresponds to the trials required by a subject to master the double alternation problem Secondly, the subject must utilize this formula in writing additional numbers of the series This corresponds to the extension of series test in the double alternation problem where the subject must also utilize a formula, secured in successive trials on a series of given length, to make additional responses in an extended series. It will be noted that in the double alternation problem the extension tests are presented without warning or instructions to the subject, whereas in the mental tests specific instructions to "write the two numbers that should come next" are given This, however, does not appear to be a significant difference in the two situations. There is a close resemblance between the double alternation extension of series tests and the following sample *taken from the X-0 Series test Form 0 of Group Examination Beta* (9, p. 253)

7	O	O	X	X	O	O	X	X	O	O	X	X				

Here the subject should add 00 and XX, while in the similar double alternation test he should respond *R R* and *L L*. This general type of extension problem is commonly recognized to involve thinking, which is largely, if not wholly, a matter of language responses. These language responses are themselves symbolic processes which in man are most highly developed in the form of verbal behavior. Thus it appears that ability to successfully *extend* the double alternation of responses beyond the length of the training series, as well as ability to *learn* double alternation, may be considered as an indication of the presence in subjects of symbolic processes

3 *Controls for Possible External Cues* Following the tests on extended series, three controls were introduced to discover whether

the subjects were dependent in their double alternation of responses upon cues from the experimenter or from the apparatus itself. In addition to the results of these controls, I present below an analysis of certain forms of behavior which were related to the factors for which controls were introduced. Preceding these controls each animal was given five additional practice trials. Goofy, Squeak, and Bones each made one error on one of these five trials, but Daisy performed them all correctly. Before proceeding to the description of the controls used, let us analyze the apparatus and its manipulation in order to discover possible sources of cues that the subjects might be receiving which would enable them to perform the double alternation problem successfully. It must be granted that the first response is somewhat different from the others in that it follows the release of the animal from the front of the apparatus, whereas the other responses follow the taking of grapes from one box or the other. However, no control needs to be introduced in this connection since the principle of double alternation is not involved at this point in the trial. Visual stimuli from within the cage are identical from response to response. Preceding each response both boxes are closed, and there is nothing movable except the lids of the boxes. Outside the apparatus one variable factor did exist. This was the food carriage which projected 9 inches to the left of the apparatus at the beginning of each trial and was moved 2¼ inches toward the right following each response. During responses 7 and 8 the food carriage was in view on the right side of the apparatus. A control of this factor will be described later. No other apparent visual cues existed. Olfactory cues are improbable in that all compartments of the food carriage contained grapes on each trial. Hence the odor of food was present in both boxes at all times. The movement of the lids could give no differential auditory cues. The food carriage was moved one section before each response, and presumably made no differential sounds during this movement.

Since different keys unlocked the boxes, it seems possible that differential cues could originate in them. It was necessary that this factor be controlled before the alternation box-apparatus could be accepted as a satisfactory test of double alternation. To test for this possible cue the following control tests were made.

Control 1. In this control both keys were depressed and not moved again during the entire trial. Both boxes were thus unlocked and the subject could open either box on each response. Each sub-

ject was given 10 trials with this control. Goofy performed 8 of these trials correctly. Bones made an error on his first trial with this control but performed the last 9 trials correctly Daisy and Squeak made no errors during the 10 trials with this control. These results indicate that the monkeys were not dependent in their double alternation of responses upon differential cues from the keys which unlocked the boxes Altogether there were only 7 errors out of 320 responses during Control 1

At the time each monkey finished the first control he was performing the double alternation of 8 responses correctly and very rapidly This led to a form of behavior which for a time appeared as a possible differential factor It consisted in the fact that the subjects frequently tried to hold open the box lids following responses 1, 3, 5, and 7, i e, following the first of each pair of responses, *R* or *L*. Was this inherent in the increased speed with which the subjects were now working, or was it a source of differential cues which made the performance of the double alternation problem possible for the monkeys? If the latter were true the situation would be as follows. On the first response (to the *R*) the subject would encounter a completely closed box and this would lead to a second response (to the *R*) But during this response he would have been making an effort to hold the box open and this situation would call out a turn to the left for the third response Here the closed left box would be encountered preceding the third response (to the *L*), and the left box being held open would be encountered preceding the fourth response (to the *L*) That is, preceding the first of each pair of responses on either side, the box on that side would be *closed* and this would call out a second response to the same side Preceding and during this second response, the box was *being held open* and this situation would call out alternation to the other side. I decided to determine just how definite this tendency was

The phenomenon appeared most definitely in the case of Goofy, who, as has been stated, worked the most rapidly of any subject. He was given 25 trials during which careful records were kept of his "holding" behavior Records for the other subjects were kept for 5 trials each. If this "holding" behavior were playing an important part in the determination of the double alternation of responses, it should appear for each subject in a large percentage of the odd-numbered responses Table 6 shows that this is not the case. The

TABLE 6
TOTAL NUMBER AND PERCENTAGE OF TIMES BOXES WERE HELD ON ODD-NUMBERED RESPONSES BY EACH SUBJECT

Subject	Number	Percentage
Daisy	5 in 20	25
Bones	8 in 20	40
Goofy	45 in 100	45
Squeak	13 in 20	65

percentage of boxes held open by each subject on odd-numbered responses is small with all subjects except Squeak

Table 7 shows the number of trials during this analysis of behavior in which the subjects tried to hold open various numbers of boxes In one trial the subject could have held from 0 to 8 boxes Squeak was the only subject who held at least one box on every trial Goofy was the only subject who held 4 boxes open on several trials From this table it appears that 1 or 2 boxes were held in a typical trial Goofy held not only odd-numbered boxes, but on 3 occasions held even-numbered boxes for very brief periods of time. Squeak's record shows the greatest percentage of odd-numbered boxes held. The trials on which these data were tabulated for him were given following Control 2 (to be described below) It may be that something in the nature of that control led to the results found for Squeak here. These records demonstrate clearly that no animal invariably held the odd-numbered boxes

Table 8 shows the total incidence of holding occurring on each of the odd-numbered responses during this analysis of behavior Only the first box was held open a large percentage of times, and even it was not held invariably Furthermore, the third response

TABLE 7
NUMBER OF TRIALS IN WHICH DIFFERENT SUBJECTS TRIED TO HOLD OPEN FROM 0 TO 4 BOXES

Number of boxes held per trial	Number of trials for different subjects Daisy in 5	Squeak in 5	Bones in 5	Goofy in 25	Total in 40
0	1	0	2	1	4
1	3	1	0	9	13
2	1	0	2	10	13
3	0	4	0	1	5
4	0	0	1	4	5

TABLE 8
TOTAL NUMBER AND PERCENTAGE OF TRIALS ON WHICH BOXES WERE HELD OPEN ON ODD-NUMBERED RESPONSES

Response	Number of times in 40 trials	Percentage of 40 trials
1	31	77
3	18	45
5	10	25
7	12	30

involved this holding behavior in less than one-half of these trials, and responses 5 and 7 even a smaller percentage. Goofy held the first box 23 out of 25 times No other subject held on the first response more than on other odd-numbered responses. It is evident that the holding behavior under consideration appeared too irregularly and infrequently to serve as the controlling factor in the double alternation of responses. Furthermore, it appeared late in the experiment *after* the double alternation of responses had been mastered It is likely that this holding behavior was merely a function of the speed at which the subjects attempted to work

Control 2. As a further check on whether the position of the lids of the boxes played an important rôle in controlling the double alternation of responses, I carried out the following control with Daisy, Squeak, and Bones.[2] In this control the subject was prevented from holding the box lids open *since the boxes were held open by the experimenter* at the times during the trial when holding behavior was likely to take place The lid of each box was held open by the experimenter after it had been opened by the subject, and was allowed to fall only after the subject had turned away from this open box to the other (closed) box If the holding of boxes were playing an important causal part in the double alternation of responses, this control should upset the subjects, since in it holding behavior was prevented by keeping the boxes open Even if the subjects were not responding in double alternation from cues received from holding the box lids, it seemed likely that an open box following the second of each pair of responses on either side would cause the animal to wait for another grape at that point. If, on the other

[2]As stated above, Squeak took this control before the analysis of behavior which followed Control 1 for the other subjects Goofy was not tested on this control, as he had been started on another problem

hand, the subject *turned sharply away from one box* (which was being held open) after taking his second grape, and opened the other box (which was closed), it would definitely indicate that the monkeys were not dependent upon the positions of the lids of the boxes for the control of their double alternation of responses

Let us now consider the results secured in Control 2 Squeak hesitated slightly after taking his second and fourth grapes on his first trial. Thereafter *all of his turns following even-numbered* grapes were very sharp After taking the first grape from each box, he *waited for another*, even though *I delayed in moving the* food carriage After taking the second grape, however, he immediately turned and opened the other box This indicates definitely that he was performing the problem with a well-established habit of double alternation Bones made no pause after response 2 of his first trial in this control Following response 4 he turned to *R*, put paused slightly before opening that box After response 6 he "*looked*" *into the R box before turning to L*[3] *Thereafter he made* all turns following even-numbered responses quickly and sharply Daisy did not hesitate at all during this control. All of her turns were very sharp following even-numbered responses. On her last trial on this control I delayed presenting food for responses 6 and 8 for several seconds to see if she would fail to wait for a second grape on the *R* and *L* respectively She not only waited, but put her head down very close to the boxes. After receiving the second grape in each case, however, she turned at once to the other box On this *trial she made a definite ninth response to the R* *The results of this* control indicate clearly that nothing in the position or operation of the box lids, or in the speed with which the food carriage was moved, was controlling the double alternation of responses in the monkeys

Control 3 The only other feature of the apparatus which seemed to be a possible source of differential cues throughout the series of responses on each trial was the fact that the food *carriage* was usually moved from the left to the right So far as I could *observe none* of the subjects reacted to the portions of the food carriage extending to either side of the apparatus, after the first few

[3]By "looked" I mean a reaction which seems typical with rhesus monkeys Bones twisted his head to the side and lowered it directly toward the bottom of the open box in a quick movement This reaction is usually accompanied by an extension of the hind-limbs

trials of the experiment during which habituation to the problem took place. (It would have been possible to cover the platform on which the food carriage moved, but this would not have controlled any auditory cues inherent in the operation of this part of the apparatus.) Tests were made to determine whether the projection of the food carriage out to the side of the apparatus influenced the behavior of the monkeys. In these tests the food carriage was operated from right to left and extended out from the apparatus in a different fashion with respect to the series of responses than was usually the case This control was introduced on three trials In no case was any change in behavior apparent with any of the subjects

In addition to the evidence gained in the control tests, certain other features of the experiment indicate that the subjects were not responding to cues from the experimenter, or from the apparatus. At no time throughout the experiment did the animals give any evidence of receiving visual cues from the experimenter On a number of occasions other persons than the experimenter observed the monkeys work So long as these persons made no sound, and were separated from the subject by the panelled side of the apparatus and the screen, no disturbance in the subject's performance was noted. On various trials I followed the plan of varying the operation of the apparatus by a change of the position at which I sat and the hands with which I operated the different parts of the apparatus On one day I weighted the levers which controlled the box lids in such a way that the lids fell very quickly No change in the behavior of the subjects was noted All of these points lead to the same general conclusion, that the double alternation box-apparatus is a satisfactory and efficient means of testing subjects on the double alternation problem, since it gives no cues which might be used by the subject in the *control* of the double alternation of responses

During the trials on 16 responses a very interesting form of behavior appeared. In order to present 16 grapes it was necessary to move the food carriage in an unusual fashion. It must be moved once to the right, once to the left, and thereafter three times to the right and once to the left, etc I practiced this procedure several times but in the trials with three monkeys I made mistakes in moving the food carriage. The result was that on the 16th response for each of these animals an empty food compartment was presented Instead of turning to the other box the monkeys looked and looked into the

empty box. Bones twisted his head to the side and put it down close to the box. Then he looked behind the opened lid and again into the box.[1] He made no move to turn to the other side. Similar behavior appeared with Goofy and with Squeak. This is a definite exhibition of a double alternation tendency, in that the animals did not turn away at once as they would have done had they secured a second grape from this box. It is true that the empty box presented different stimuli than one containing a grape. However, the monkeys encountered open, empty boxes during Control 2, after taking *two* grapes from the same box, and behaved in an entirely different manner. Control 2 demonstrated that, after learning double alternation, the monkey will not stay at an open box after getting two grapes from it, and the behavior described above, together with that found for Daisy on her last trial on Control 2, indicates that the monkey will stay at one box until it has received the second grape. Such performance indicates that the double alternation of responses in the monkey is controlled by some process within the animal. It does not indicate whether this process tends to represent the cumulative effect of previous responses during the trial or the general pattern of the total response to be made.

Summary and Conclusions

In this experiment four monkeys were trained in the double alternation of a series of eight responses, *R R L L R R L L*, with a new alternation box-apparatus. This apparatus consists of two small boxes built inside a cage upon the top of a table. During the experiment the animal sits before or between these boxes, and should open their lids in the order stated above, thereby securing bits of food. The apparatus is adapted to the study of double alternation in much the same way as is the temporal maze, in that the response of opening a box, taking a grape, and allowing the lid of the box to close, is equivalent to a trip around one side of the temporal maze. Throughout the experiment the monkeys were very tame and could be handled with ease. This fact is of importance, since it contributed toward the excellent results which were secured in this experiment.

All of the subjects mastered the double alternation problem in from 72 to 134 trials. Early in learning the typical series of re-

[1]One is somewhat reminded of the results obtained by Tinklepaugh (8) in his study of qualitative representative factors when his monkeys found lettuce in containers in which bananas had apparently been placed.

sponses was *R L L R R L L R*, in which the odd-numbered responses are correct This type of series has been called "alternation after success" by Hunter (6) In view of the fact that during this series the subject tries first one side (box) and then the other (box) as rapidly as possible, this form of response should be described as a *simple alternation of reactions* rather than as "alternation after success" This interpretation is also applicable to the same series of responses in the temporal maze

During learning three of the subjects encountered more difficulty with the even-numbered responses than with the odd-numbered responses This is the usual result in the double alternation problem, since mastery of this problem apparently consists in the subject learning to break down the simple alternation of reactions described above A situation quite different from this was found in the fourth subject, who exhibited a tendency toward *double alternation* from an early point in the experiment During learning this animal passed successively through the following series in the fixation of correct responses:

R — — — R — — —
R R — — R R — —
R R L — R R L —
R R L L R R L L

In these series the responses indicated by letters were the same (and correct) trial after trial, and the responses indicated by dashes were sometimes *R* and sometimes *L*. The subject who exhibited this behavior was the only monkey who had received previous training in the double alternation of responses, but there is no way of knowing whether in the case of this subject the double alternation of responses carried over from his mastery of the temporal maze.

After learning, each subject was trained until he could perform 10 correct trials, of 8 responses each, in succession. He was then tested upon series of responses longer than the training series (i.e., trials with from 12 to 16 responses each) All subjects performed these longer trials perfectly, thus indicating that the double alternation of responses in these subjects was not limited to the length of the training series. An analysis of this extension test shows that ability to *extend* the double alternation of responses beyond the length of the training series as well as ability to *learn* double alternation may be considered as an indication of the presence in subjects of symbolic processes.

Controls were introduced to test whether the subjects were dependent in their double alternation of responses upon cues from the experimenter or from the apparatus itself. The double alternation behavior of the subjects was not changed in any way by these controls. *The fact that the subjects were responding in double alternation in the absence of differential or proprioceptive stimuli* received in the experimental situation indicates that their behavior was controlled by some symbolic process or some central neural process.

Why were the results secured in the present experiment so much more positive than those secured with monkeys in the temporal maze (1)? I believe the difference is due to the apparatus used in the present experiment. There are several factors which contribute to the greater ease with which the monkey can learn the double alternation problem in the alternation box-apparatus than in the temporal maze Instead of locomotion, the use of the fore limbs is required, and the monkey is adept in this respect. Food is secured immediately *following each response in the box-apparatus, while in the temporal maze the animal must proceed to the front of the apparatus* before securing food. Finally, the responses follow one another much more quickly in the box-apparatus than in the temporal maze. The best time for 4 responses in the temporal maze was 33 seconds, while 8 responses have been completed in the alternation box-apparatus in 9 seconds. It seems likely that the alternation box-apparatus experiment will be better suited for work with young children than the temporal maze was found to be (2).

The results of the present experiment make possible the following conclusions:

1. The monkey can master the double alternation problem in the alternation box-apparatus very decisively.
2. Following learning these subjects can extend this double alternation of responses to series of greater length than the series upon which they were trained
3. The double alternation of responses under these experimental conditions is independent of cues from the experimenter and from the apparatus itself

These results indicate that the alternation box-apparatus may be placed with the temporal maze as a valid method of testing for ability to perform double alternation, and thus for demonstrating the presence of symbolic processes

General Conclusions

In general, the results of the three experiments of this series bear out the position taken by Hunter concerning the relationship of the double alternation problem and the delayed reaction experiment, and the explanation of the performance of the former problem in terms of symbolic processes (5). Several facts have appeared which indicate that the double alternation problem requires for its solution a different type of ability than that found in ordinary habit formation of the spatial maze type. All subjects thus far tested in the double alternation problem fall into genetic series with respect to their performance in various aspects of the problem. In some of these genetic series, rats, and, in others, human subjects are found to be at the top.

Human subjects who solve the double alternation problem all formulate it verbally in the general form, "two to the right, two to the left, etc." The exact time relationship of this behavior and the solution of the problem is not yet known. The symbolic processes utilized by human subjects to supplement the non-differential stimuli encountered during the performance of double alternation are these verbal responses. In the sense that this type of symbolic processes seems most efficient in the solution of the double alternation problem, and since human subjects are most able to master this problem, the ability required to solve the problem of double alternation may be said to be "typically human."

On the other hand, in the fixation of the first correct response of the double alternation problem following introduction into the apparatus, human subjects have proved to be less able than other subjects that have been tested upon the problem Evidently, the ability required here is of a different sort than that mentioned above This aspect of the temporal maze situation is in many respects similar to the usual spatial maze situation In it rats are found to be most, and human subjects least, able.

In the double alternation problem two general response tendencies are discernible and these appear to be mutually opposed. They are the direction tendency and the tendency toward simple alternation The human subject exhibits the former of these tendencies only slightly, and the latter very definitely With the rat, the situation is just the reverse of this.

All of these differences in the double alternation behavior of different subjects indicate that the double alternation problem requires in its solution an ability which is present in the highest degree

TABLE 9
RELATIVE ABILITY DEMONSTRATED BY DIFFERENT SUBJECTS IN THE DELAYED REACTION AND IN THE DOUBLE ALTERNATION PROBLEM AND RELATIVE PROMINENCE OF VARIOUS TYPES OF BEHAVIOR EXHIBITED IN LEARNING THE DOUBLE ALTERNATION PROBLEM

	Relative order from most to least			
Type of behavior	Human subjects	Monkeys	Raccoons	Rats
Delayed reaction	1	2	3	4
Double alternation	1	2	3	4
Extension of series	1	2	3	3
Simple alternation behavior (*R L L R*)	1	2	3	4
Direction tendency (*R L L L*)	4	3	2	1
Association of first turn and entrance	4	3	2	1

in human subjects, less in monkeys, still less in raccoons, and least of all in rats. Some of the evidence indicates that a certain type of ability (presumably required in the usual spatial maze) is possessed by these same subjects in about the reverse order of that stated above. Table 9 indicates the order into which these subjects fall in respect to the abilities they have demonstrated in the types of behavior we have been discussing throughout this series of experiments These facts, added to Hunter's theoretical analysis (5), lead to the general conclusion that the double alternation problem may be placed with the delayed reaction experiment as a valid method of testing for the presence of symbolic processes in human and infrahuman subjects

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LE PROBLÈME DE L'ALTERNATION DOUBLE
III LE COMPORTEMENT DES SINGES DANS UN APPAREIL DE BOITES À ALTERNATION DOUBLE

(Résumé)

On a entraîne quatre singes rhesus dans un appareil nouveau de boîte à alternation double lequel est original dans cette enquête Cet appareil se compose de deux petites boîtes construites dans une cage sur le haut d'une table. Pendant l'expérience l'animal reste assis devant ou entre ces boîtes, et doit en ouvrir les couvercles en l'ordre *D D G G D D G G*, obtenant ainsi des morceaux de nourriture L'appareil est adapté à l'étude de l'alternation double d'à peu près la même manière que le labyrinthe temporel Tous les sujets ont résolu le problème en de 72 a 134 epreuves. Les contrôles ont montré que les sujets repondaient en alternation double sans l'aide des stimuli differentiels extéroceptifs et proprioceptifs de l'appareil.

Très tôt dans l'apprentissage la série type des réponses ont ete *D G G D D G G D*, ou les réponses impaires sont correctes. Ce type de series a été appelé par Hunter "l'alternation après le succès" En vue du fait que pendant cette série le sujet essaie premièrement une boîte et ensuite l'autre aussi vite que possible, on doit décrire cette forme de réponse comme le *comportement d'alternation simple.* On peut appliquer cette interprétation aussi à la même série de réponses dans le labyrinthe temporel

Pendant l'apprentissage trois des sujets ont trouvé plus de difficulté avec les réponses paires qu'avec les réponses impaires C'est ici le résultat ordinaire dans le problème de l'alternation double, puisque la resolution de ce problème semble dépendre du fait que le sujet apprend à rompre l'alternation simple des réactions décrite ci-dessus. Le quatrième sujet, cependant, a montré une tendance vers *l'alternation double* de bonne heure dans l'expérience Ce singe avait préalablement appris le labyrinthe temporel à alternation double

Après l'apprentissage on a testé chaque sujet sur des séries de 12 à 16 réponses. Tous les sujets ont subi parfaitement ces épreuves plus longues, indiquant ainsi que l'alternation double des réponses chez ces sujets n'a pas été limitée à la longueur des séries d'entraînement

Plusieurs facteurs contribuent à la plus grande facilité avec laquelle le singe peut apprendre le problème de l'alternation double dans l'appareil de boîtes pour l'alternation que dans le labyrinthe temporel. Au lieu de la locomotion l'usage des avant-bras est exige et le singe est habile à cet egard. Il obtient de la nourriture immédiatement après chaque reponse dans l'appareil de boîtes tandis que dans le labyrinthe temporel il faut que l'animal aille au devant de l'appareil avant d'obtenir de la nourriture Enfin, les

réponses suivant l'une l'autre beaucoup plus vite dans l'appareil de boîtes que dans le labyrinthe temporel

Ces résultats indiquent que l'appareil de boîtes pour l'alternation peut être placé avec le labyrinthe temporel comme une méthode de valeur pour tester la capacité d'exécuter l'alternation double, et ainsi pour montrer la presence des processus symboliques

GELLERMANN

DAS PROBLEM DER DOPPELTEN WECHSELFOLGE
III DIE TATIGKEIT VON AFFEN IN EINEM KISTENAPPARAT ZUR UNTERSUCHUNG DER DOPPELTEN WECHSELFOLGE (DOUBLE ALTERNATION BOX-APPARATUS)

(*Referat*)

*Es wurden vier macacus rhesus Affen dressiert in einem fur diese Un*tersuchung neu erfundenen Apparat fur doppelte Wechselfolge Dieses Apparat besteht aus zwei kleinen Kisten welche innerhalb eines Kafigs auf einem Tisch aufgebaut worden sind Wahrend des Versuches sitzt das Tier vor oder zwischen diesen Kisten Es soll die Deckel der Kisten offnen *in der Reihenfolge rechts, rechts, links, links, rechts, rechts, links,* links, und auf diese Weise Stuckchen Nahrung erreichen Das Apparat ist zur Untersuchung der doppelten Wechselfolge so ziemlich auf die selbe Weise geeignet wie es das Zeitlabyrinth (temporal maze) ist Alle Versuchstiere bemeisterten das Problem in 72 bis 134 Versuchen, Versuche an Kontrolltieren erwiesen, das die Tiere in doppelter Wechselfolge reagierten obwohl sie durch differenzierende ausserliche (exteroceptive) und innerliche (proprioceptive) Reize von dem Apparat aus keine Hilfe erhielten

Am Anfang des Lernens war die typische Reaktionsserie R L L R R L L R, wobei die erste, dritte, funfte u s w. (odd-numbered) Reaction richtig war Diese Serienform ist von Hunter "Wechsel nach Erfolg" (alternation after success) genannt worden. Da das Versuchstier wahrend dieser Serie wirklich zuerst die eine und dann die andere Kiste so schnell wie moglich versucht, *so soll diese Reaktionsform als einfache Wechseltatigkeit beschrieben* werden (simple alternation behavior) Diese Deutung lasst sich auch auf die selbe Reaktionsserie in dem Zeitlabyrinth ubertragen

Wahrend des Lernens fanden 3 der Versuchstiere die mit gleichen Zahlen nummerierten Reaktionen schwieriger als die mit ungleichen Zahlen nummerierten. *Dieser Befund ist bei der Aufgabe der doppelten Wechselfolge* der gewohnliche, da Meisterschaft uber diese Aufgabe darin zu bestehen scheint, dass das Versuchstier lernt, die oben beschriebene einfache Wechselfolge der Reaktionen zu zerstoren. Das vierte Versuchstier, aber, erwies schon fruh in der Untersuchung eine Neigung zur doppelten Wechselfolge *Dieser Affe hatte fruher das Zeitlabyrinth mit doppelten Wechselfolge be*meistert.

Nach dem Lernen wurde jedes Versuchstier an einer Serie bestehend aus 12 bis 16 Reaktionen gepruft. Alle Versuchstiere machten diese langen Versuche ganz richtig Sie deuteten auf diese Weise an, dass die doppelte *Wechselfolge der Reaktionen sich bei disen Versuchstieren nicht auf die* Lange der Dressierungsserie beschrankte

Die Grunde der Tatsache, dass der Affe das Problem der doppelten Wechselfolge in dem Kistenwechselfogeapparat schneller bemeistert als in dem Zeitlabyrinth sind verschieden 1) Anstatt des Laufens verlangt

das Kistenapparat den Gebrauch der Vorderpfoten, worin der Affe sehr gewandt ist 2) In dem Kistenapparat erhalt das Tier die Nahrung sofort nach jeder Reaktion, wahrend in dem Zeitlabyrinth das Tier zuerst zur Vorderseite des Apparates gehen muss ehe es die Nahrung erhalt 3) Schliesslich folgen die Reaktionen im Kistenapparat vil rascher aufeinander als in dem Zeitlabyrinth.

Diese Befunde weisen darauf hin, dass das Kistenapparat zur Untersuch ung der Wechselfolge sich an die Seite des Zeitlabyrinthes stellen lasst als ine triftige Methode, mit der sich die Fahigkeit, eine doppelte Wechselfolge zu bemeistern, erproben lasst, und womit also die Anwesehcit symbolischer Vorgange (symbolic processes) erwiesen werden kann.

GELLERMANN

SHORT ARTICLES AND NOTES

A PRELIMINARY STUDY OF THE REACTIONS OF TWO-YEAR-OLD CHILDREN TO EACH OTHER WHEN PAIRED IN A SEMI-CONTROLLED SITUATION

IDA GAARDER MENGERT

PURPOSE

The purpose of this study was to develop a method for observing the social behavior of young children which would also be of use as an educational aid in modifying the behavior of the children

METHOD

The method is based upon an experiment in social behavior conducted by Berne (1) There is, however, some variation Two children, known as a pair, *were taken into a small room at a time and told* they might play with anything they liked Play materials were available, in duplication of materials in the preschool-group room Each child was paired with each of the nine other children, making a total of 45 pairs The observer closed the door and observed the children *through a screen, unobserved by them*, recording the behavior of each of the children in running notes, minute by minute, during a 20-minute period Later, this material was tabulated, and the child's final score in friendliness was made up from these tabulations

The following behavior was included under the general term of "overt *friendly behavior*"

> Talks to partner in friendly manner, replies to partner's speech, gives toys to partner or offers to do so, includes partner in *his projects*, *e g*, "*Let's make the bed*", "*Both two play with* clay", helps partner by definite aid, or by suggestion, calls the attention of the other child to what he is doing

The following behavior was *included under the general term of* "overt unfriendly behavior".

> *Threatens, by speech or gesture, hits, pushes, pulls hair,* pinches, does not answer, snatches, refuses to share material, or to work with partner or let partner work with him, destroys other's construction

Since all the children were observed for the same length of time, one point was given for each instance of overt behavior, friendly or unfriendly, in the minute in which it occurred. The minute was the unit. To obtain the friendliness score for each child, the *total overt unfriendly behavior* was subtracted from the total overt friendly behavior.

Subjects

Ten two-year-old children in the preschool laboratories of the Iowa Child Welfare Research Station, nine of them from one group, and the tenth, known as the test subject, from another group.

Results

The influence of the behavior of the partner on the subject's following behavior was discernible in many cases, but no quantitative analysis could be made of this factor.

The adults' influence was reflected in the speech content of the children in 53 recorded instances.

When material relating to overt friendly and unfriendly behavior was tabulated, it was found that the average score for overt friendly behavior was 89.5 as opposed to 20.5 for overt unfriendly behavior (Table 1).

TABLE 1

NUMBER, TOTAL, AND MEAN SCORES OF TEN CHILDREN ON BEHAVIOR ITEMS OBSERVED DURING OBSERVATION PERIOD

	Behavior items					
Child	Watching	Overt friendly	Overt unfriendly	Overt friendly minus overt unfriendly	Overt friendly minus sociability	Refusal to share plus disregard for property rights
A	17	78	56	22	21	18
B	16	110	2	108	37	00
C	5	91	12	79	34	00
D	3	103	7	96	36	3
E	5	81	33	48	18	12
F	12	74	26	48	25	14
G	13	107	3	104	23	1
H	17	74	9	65	28	2
I	35	82	39	43	22	18
J	26	95	18	77	54	12
Total	149	895	205	690	298	80
Mean	14.9	89.5	20.5	69.0	29.8	8.0

The average score for overt friendly behavior was significantly larger for the last three observations than for the first three when Fisher's formula was applied to the means. The scores for overt unfriendly behavior and disregard for property rights were smaller, but probably not significantly so. When the unfriendly was subtracted from the friendly behavior scores, and Fisher's formula was applied to the averages for the first three and last three observations, the mean for the last three was significantly higher (Table 2).

TABLE 2

SCORES t AND P FOR ITEMS OF BEHAVIOR IN THE FIRST THREE AND LAST THREE OBSERVATIONS

	Observations			
Behavior items	First three	Last three	t	P when $n=18$
Overt friendly	26.8	33.9	1.92	.05
Overt unfriendly	7.7	4.3	1.33	.2
Friendly minus unfriendly	19.1	29.6	2.11	.05
Disregard for property rights	4.0	1.4	.63	.5

There was considerable consistency in the behavior of the individual children, as shown by the maintenance of relative position in the group. The rankings in the first three and the last three observations are given below:

	Observations	
Behavior items	First three	Last three
	Children	
Friendly		
Average or above	B, G, J	
Average or above		B, G, J, A, D
Unfriendly		
Below average	B, G, C, D, H	
Below average		B, G, D, H, J

When the unfriendly was subtracted from the friendly behavior, and when the total of the friendly and unfriendly behavior was considered, the following rankings were found:

Friendly minus unfriendly	
Average or above	B, G, C, D, J
Total friendly	
Average or above	B, G, C, D, J
Total unfriendly	
Below average	B, G, C, D, H, J

The following rankings were obtained when disregard for property rights plus refusal to share were added together

Disregard for property rights plus
Refusal to share
Below average — B, G, C, D, H

When the unfriendly behavior toward others was subtracted from the friendly behavior of the child and divided by the unfriendly behavior toward self subtracted from the friendly behavior toward self the following results were obtained:

Friendly minus unfriendly
toward others
divided by
Friendly minus unfriendly
toward self
Above average — B, C, D, G, H, J

A negative relationship was found between total overt friendly behavior manifested by the subject and total overt friendly behavior manifested toward him by the rest of the group in the cases of the children having the three highest and three lowest total friendly scores. This is given in Table 3 which shows a comparison for individual children between friendliness toward others and friendliness received from others when unfriendly was subtracted from friendly behavior.

TABLE 3

COMPARISON OF FRIENDLINESS TOWARD OTHERS AND FRIENDLINESS RECEIVED FROM OTHERS

Child	Toward others	From others
A	22	94
B	108	49
C	79	64
D	96	58
E	48	86
F	48	86
G	104	67
H	65	65
I	43	59
J	77	62
Mean	69	69

The total behavior scores shown toward individual children are given in Table 4.

By the rank order method a positive correlation (.90±.04) was obtained for friendliness with intelligence quotient, a low positive correlation (.29±.02) with mental age, and a low negative correlation (—.49±.16) with chronological age. These results are suggestive for further study, but in nowise conclusive in themselves, since with but ten cases there is a strong possibility that chance operated to make this a selected group.

TABLE 4
TOTAL BEHAVIOR SCORES SHOWN TOWARD INDIVIDUAL CHILDREN

Child	Overt friendly	Overt unfriendly	Overt friendly minus overt unfriendly
A	104	10	94
B	87	38	49
C	99	35	64
D	78	20	58
E	98	12	86
F	99	13	86
G	86	19	67
H	80	15	65
I	81	22	59
J	83	21	62

There seemed to be a tendency for quality of work accomplished (adult standards) to decrease with increased sociability.

Several variations in methods used by the children to keep the situation in hand were noted. In cases where a method more advanced than force was used, it was traceable to the example of the preschool or home situation

The observer feels that the method is to be preferred to observation in the usual preschool group in cases where the data desired is obtainable in either situation The situation remained constant except for the change in partner, having this advantage over the school situation The children were not interrupted by group activities, or by other children other than the partner. They also had less opportunity to evade issues, since there was no escape from the room, and no one to help them out of a difficult situation The observer, who was unobserved by the child, was in a position to see the behavior of the latter and hear his comments, without following him about. The children reacted favorably to the method In only two instances out of a total of 45 observations was it necessary to interfere, once at the end of 12 minutes, and once at the end of 18 minutes.

It is the opinion of the writer that the method is of value as a teaching aid, since (*a*) the average friendly score was greater during the last three than the first three observations for all children, (*b*) the child whose behavior changed most markedly went through the series in the shortest time (19 days as compared with 44 to 77 days for the others), (*c*) each of the nine subjects when paired with Subject A (the test subject) showed far greater tendency toward self-control and attempt to solve the difficulty rather than evade it than had been observable in the first pairing, and (*d*) one child, who in his first pairing called for help on three separate occasions when his partner snatched his clay, in his test pairing (the first for the test subject) prevented the partner from taking his materials, directed her in

her activity, explained his rights to her, and made no attempt to get aid.

The reasons for difficulties which certain children often had in the group room were discovered by this method, when they had not been perceived by the teachers during a semester. The observer was able to predict in seven out of the nine cases what the general behavior would be with the test subject. After nine 20-minute observations, the observer was able to give information to the teachers of the test subject which was of use educationally.

Summary and Conclusions

The writer feels this study demonstrates a method which is of value as one means of reducing the number of variables in an observational study It demonstrates, further, that for purposes of quantitative results it is desirable to limit the observations to certain definite behavior patterns instead of attempting to record all of the behavior, since the only material it was possible to use quantitatively in this study was that which was concentrated on in the observations The method is recommended as an educational aid in modifying behavior, but the writer would make some changes, notably more frequent pairings in the case of each child, and a more limited change in partners (These subjects were paired once each week, and with a different child each time Only the test subject was paired every day, or every other day.)

The most significant data of the study are those which reveal the relatively high scores for friendliness as compared with those for unfriendliness on the part of all members of the group, and the negative relationship between the friendliness manifested by the subject and that manifested toward him, in the cases of the children having the extreme scores The most useful part of the data is on the qualitative side, in leads and suggestions for further study in the field of social adjustment.

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A COMPARISON OF BLOOD-PRESSURE METHODS

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The recent controversy (5, 2) between Dr. Carney Landis and me regarding the use of blood-pressure in the detection of deception points to the desirability of publishing some data that was gathered some three years ago on the comparison of the phenomena measured by the intermittent and the

so-called continuous methods of obtaining blood-pressure The former method has been in use throughout the history of blood-pressure measurement. It was developed at a time when physiologists were familiar with the laws of hydraulics and careful analysis and experiment shows that this method measures the lateral pressure of the aorta (3, 4). The continuous method was developed by Larson, who was seeking a method of detecting deception which would catch all the pressure changes, many of which may be missed by the intermittent method

Larson (7, 8) used an Erlanger sphygmomanometer with the cuff pressure about constant at 90 m m Hg Larson thought that, among other things, this use of Erlanger's instrument gave him a measure of systolic blood-pressure. Both he and Landis, who subsequently used the Erlanger instrument in a similar fashion, refer to this as "the Erlanger '04 method." As I have pointed out elsewhere (2), it is difficult to understand how these investigators came by this erroneous conception, as Erlanger's papers for that year are quite devoid of any such suggestion Erlanger, as every physiologist knows, designed the instrument for intermittent use He was inter-

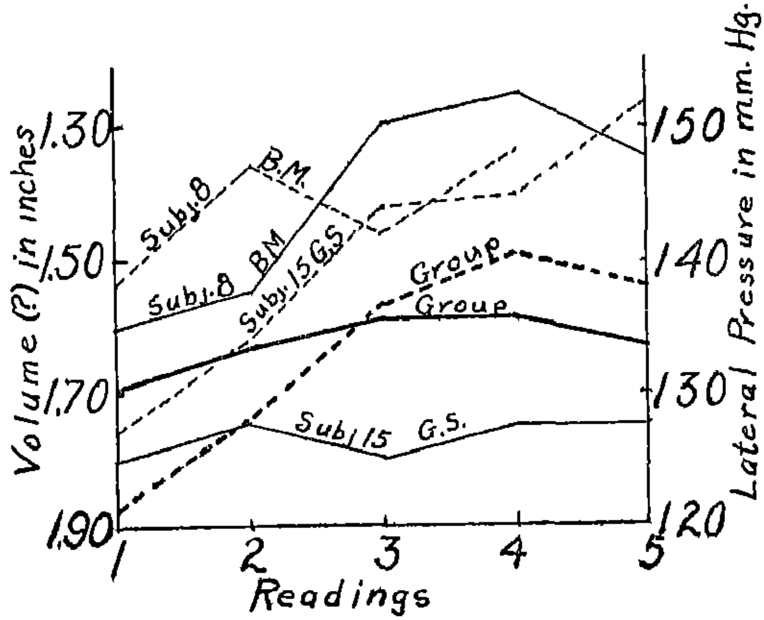

FIGURE 1

Comparison of Curves

---- Intermittent method

——— Continuous method

ested in obtaining a measure of the maximum and minimum pressures as near simultaneously as possible. Its use was not unlike that of the new Tycos Recording Instrument The cuff pressure was made great enough to stop the arterial flow from which it was decreased in regular intervals to a point below the minimum arterial pressure The maximum pressure measured by the instrument Erlanger found to be the lateral pressure of the aorta and the minimum, diastolic or resistance pressure. Erlanger did not intend that his instrument should be used continuously, and physiologists appear never to have so used it Psychologists, however, have been more optmistic, if less cautious, in its use. Thus we find Landis maintaining that the method records "change of systolic pressure, diastolic pressure, pulse pressure and the like" I see no good basis for this optimism To check the method against the intermittent method is the purpose of this investigation

The technique and procedure used here were about as explained in my previous (1) paper To obtain a continuous record I used, not the Erlanger, but a B-D manometer whose mercury column was connected to a tambour of the Leitz-McKensie polygraph by a rubber tube The polygraph has a chronograph attachment on one side and may be run at any desirable speed This apparatus and the Erlanger record similar changes when similarly used The cuff of the B-D manometer was attached to the left arm and the cuff pressure held constant at about 90 m m Hg[1] The Tycos Recording Sphygmomanometer was attached to the right arm. All of the intermittent readings were taken on one chart as in the previous investigation. Frequently, it was impossible to get five distinct readings on the chart and in such cases only four readings were taken A fifth reading of the *continuous* record was made from near the end of the record in these cases.

The situation used was that of deception as previously described and, as before, the subjects were students of Seth Low Junior College, none of whom had had previous experience with the experiment The age range was from 16 to 21 years All of the tests were made in a quiet room on the Columbia Campus

It is readily apparent that the continuous method gives not absolute, but only relative, changes. Any scale used to evaluate the record is purely arbitrary. In the present case, the change is recorded in inches, and the figures given represent the distance on the record between the middle of the pulse wave and the time line The time line is chosen rather than the edge of the paper because of the slight shifts to which the paper is liable

The data taken are given in Table 1 Columns three to seven show the successive *readings of lateral pressure and columns eight to twelve give the* corresponding volume readings. In the figure are given three pairs of

[1]My own apparatus as well as the Erlanger must be checked for air leaks very frequently The cuff bags are not designed to maintain constant pressures and may leak slightly even when new

TABLE 1

DATA TAKEN SIMULTANEOUSLY BY THE INTERMITTENT AND CONTINUOUS METHODS

	Intermittent method lateral pressure in m m Hg					Continuous method volume change in inches				
Subject	1	2	3	4	5	1	2	3	4	5
1. T L	130	132	157	159		1 60	1 60	1 60	1 55	1.60
2 H S	117	127	130	131	137	1 65	1.60	1 50	1.65	1 70
3 W K.	120	130	137	138	154	1 60	1 60	1 50	1 40	1 35
4 H. S	140	145	147	153		1 70	1 60	1.55	1 60	1 60
5. J H	121	144	141	139	148	1 70	1 60	1 60	1 55	1.55
6 P K.	108	104	122	123	126	1 60	1 40	1 40	1 30	1 45
7 I L	112	132	142	151		1 50	1 45	1 30	1 35	1 40
8 B M	138	147	142	148		1 60	1 55	1 30	1 25	1 35
9 H W	111	116	131	138	127	1 60	1 45	1 50	1 55	1 60
10 N P	127	131	146	153		1.70	1 65	1 55	1 60	1.60
11 G M	109	114	124	119		2 05	2 00	2 00	1 95	1 90
12 E. B	123	124	128	132		1 70	1.55	1 35	1 45	1.55
13 I. S	115	115	130	131	132	1 55	1 55	1 50	1 50	1 80
14 E W.	120	132	140	148		1 65	1 50	1 50	1 40	1 45
15 G S	127	134	144	145	152	1 30	1 75	1 80	1 75	1 75
16 H L	115	123	120	123		1 55	1 55	1 55	1 50	1.60
17. T E	136	152	148	170		1 65	1 55	1 40	1 65	1 80
18. B J	123	128	130	137		1.70	1 70	1 80	1.85	1 70
19 J F	117	110	130	151		1.55	1 55	1 65	1 55	1 75
20 I. R.	122	134	145	149		1 60	1.55	1 50	1 50	1 55
21 P F	115	122	129	133	144	1 75	1 75	1.75	1.75	1.70
22 B H	119	130	142	146		1 45	1.45	1 45	1 35	1.35
23 M E	115	110	122	121	127	1 60	1 60	1 60	1 65	1.65
24 T K	122	124	146	140		2 15	2 05	2 10	2 10	2 00
25 B S	137	135	135	128	140	1 85	1 85	1 85	1 85	1 85
26 B M.	133	132	153	149		1 75	1.70	1.70	1 65	1 60
27 F R	110	133	143	149		1.70	1.65	1 70	1 65	1 75
28 R C.	118	122	122	125	131	1 70	1.65	1.55	1 55	1.55
	121 4	127 9	136 6	140 3	138	1 68	1.63	1 59	1 587	1 625

curves. The group curves are plotted from the averages found at the foot of the table and those for Subjects 9 and 16 from the data given in the table The lateral pressure curves are in broken lines and the continuous change in full lines It will be borne in mind that the curves given here for the continuous change are quite as intermittent as those for lateral pressure.

The group curves are of no great significance except as they show the general correspondence and lack of it between the data taken by the two methods. In *the case of the group continuous curve, it is apparent that the* changes recorded by this method are quite haphazard and unpredictable This is shown in the general constancy In the case of Subject 9, it will be

seen that the continuous record rises steadily, while the lateral pressure is irregularly up and down In Subject 16, on the other hand, the lateral pressure rises steadily, while the continuous record remains about constant In some cases, e g., Subject 26, the two are seen to vary in close correspondence

From these data it is quite apparent that there is no very great correlation between the records obtained from the two methods, and we feel justified in concluding that the continuous method does not measure lateral pressure (or systolic) as Larson and Landis have assumed that it did. Nor is it evident that the method records any other known vascular pressure Without doubt, the record is subject to changes of "systolic pressure, diastolic pressure and pulse pressure," as well as to other factors, but it must be pointed out that in both my own records and those taken with the Erlanger instrument, it is utterly impossible to tell what factors are the cause of any given change in the record

If we consider the bare facts of the continuous record, it is apparent that only two things are recorded; the change in volume of the part of the arm under the cuff, evidenced by a change in the level of the curve, and the movement of the arterial and venous walls, reflected in each separate wave. In my previous paper I pointed out that in the maintenance of blood pressure both cardiac and vasomotor impulses must be taken into account To this it should be added that the skeletal musculature also plays an important part The influence of this factor becomes readily apparent in some unusual experimental and pathological conditions Its influence is very difficult to determine and is usually neglected Care should, therefore, be taken to avoid any skeletal changes during a test In those pages I demonstrated that it was theoretically quite possible to have an increase in volume attended by a decrease in lateral pressure In the present investigation this is demonstrated practically The so-called "continuous method of recording blood pressure" does not record pressure changes. When the Erlanger instrument is so used it becomes nothing more nor less than a high pressure plethysmograph and the record is that of volume change. As a plethysmograph, the instrument is undesirable because of the high pressure The pressure of 90 m m Hg is far above the pressure of venous collapse and well below the lateral pressure of the arteries Thus, with the veins closed by the band, they soon become engorged with blood and the lateral pressure of the veins is raised to just over 90 m m Hg, the pressure necessary for a venous flow past the cuff This pressure on the veins is not safe, and rupture of the small veins is frequently observed

It is true that a change in pressure must attend a change in the volume except in unusual conditions, but it is quite erroneous to assume that the attending pressure change is identical with or even proportional to either the true systolic pressure or to the lateral pressure of the aorta The factor of venous flow so complicates the picture that this assumption is obviously

falacious In this connection it is well to bear in mind the factors entering into the maintenance of blood pressure.

The present findings may be summed up as follows

1. The continuous method developed by Larson and later used by Landis does not record or indicate any known blood pressure

2. The apparatus is a high pressure plethysmograph and, as such, may cause venous rupture

3 The volume and the pressure changes in the arm are relatively independent, and one may not be used as an index of the other

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THE EFFECT OF VARIATION IN LENGTH OF A HIGH-RELIEF FINGER MAZE UPON RATE OF LEARNING

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Warner and Hamilton (7) trained rats in mazes of 2, 4, 6, 8, and 10 culs-de-sac, respectively, but preserving a uniformity of pattern in other respects From an analysis of the results, they conclude that the longer mazes are relatively easier to learn, i.e, that the difficulty of the learning per maze unit varies inversely as the number of culs-de-sac included in the maze This relationship is, of course, quite the opposite of that obtained in the memorization of serial language material (4)

They call attention to the fact that practically nothing has yet been done along the line of determining the relative difficulty of serial patterns of various length in the field of animal or human motor learning The prin-

cipal reason which they give for this neglect is the difficulty of varying the length in a purely quantitative manner without introducing other variable conditions such as pattern complexity in a qualitative sense. This difficulty they claim to have overcome by the use of the Warner-Warden linear-pattern maze The linear design is bilaterally symmetrical with alternating right-left turns

The present study consists essentially of a repetition, with human subjects, of the experiment by Warden and Hamilton, the purpose being to examine the possibilities of the Warner-Warden linear-pattern maze for the investigation of human serial motor learning. This pattern was converted into a high-relief finger maze for use in the present experiment For a full description of the method of construction of the high-relief finger maze the reader is referred to Miles (2) and also to an earlier article by the author (1). Lengths of 4, 6, 8, and 10 culs-de-sac were used Eighty students (in groups of 20 each) who had had general psychology and, at the time of the experiment, were taking child psychology, served as subjects. The method and technique commonly used in human maze learning, which has been fully described elsewhere (1) and (3), were carefully observed in this experiment

In the light of recent experimental work on the reliability of the measuring instrument, in animal and human motor learning, it was thought wise to consider the reliability of the various length patterns used in this experiment The reliability coefficients for the four lengths used (4, 6, 8, and 10) are given in Table 1 These reliability coefficients were obtained by cor-

TABLE 1
RELIABILITY COEFFICIENTS* FOR THE VARIOUS LENGTHS
$N=20$

Length	4	6	8	10
Correlation	64± 06	.78± 04	.77± 04	71± 05

relating the total number of errors made on the odd trials with a like number made on the even trials An examination of this table will reveal the fact that the Warner-Warden linear maze, when converted into a high-relief finger maze of the same pattern, does not yield reliability coefficients as high as some of the better mazes in use today (6). This undoubtedly means that this pattern, when used as a finger maze, is too easy to yield a

*The coefficients appearing in Table 1 have been corrected by the Spearman-Brown formula $R = \dfrac{nr}{1 + (n-1)r}$ Then PE's were computed from the formula derived by Shen (5)

$$PE_R = .6745 \frac{2\,(1-r^2)}{\sqrt{N}\,(1+r)^2}$$

high degree of reliability. It has been shown by the author (1), in an earlier article, that the difficulty of the pattern is at least one of the factors determining the reliability of a maze The 6- and 8-cul-de-sac lengths are the most reliable, and an increase in length up to 10 culs-de-sac or a decrease to 4 does not result in an increase in the reliability coefficient.

The results of the effect of increasing the length of the pattern upon the difficulty of learning are shown in Tables 2, 3, and 4 These results are based on the total number of trials, errors, and amount of time (seconds) required to learn the various patterns to the point of four errorless trials in succession In addition to the absolute score, the score per cul-de-sac and the percentage score of all lengths, in terms of the 4-cul-de-sac length taken as 100%, is given for each measure obtained (Warden) Table 2

TABLE 2

COMPARISON OF THE TOTAL TRIALS REQUIRED TO LEARN MAZES OF UNIFORM PATTERN BUT VARYING IN LENGTH

$N=20$

Length	Mean	$M\ V$	V	% 4-culs-de-sac size	Score per cul-de-sac
4	9 8	2.8	29	100	2 5
6	9 1	2 6	.29	93	1.5
8	13 2	2.8	21	135	1 7
10	14 1	6 5	.46	144	1 4

shows the results in terms of the total number of trials required to learn the various lengths In terms of the absolute score, i e, the average number of trials required for learning, there is practically no difference in difficulty between the 4- and 6-cul-de-sac lengths and likewise between the 8- and 10-. When the score per cul-de-sac, however, is considered, the 4- is the most difficult and the 10- is the least difficult The order of decreasing difficulty, however, is not completely uniform The difference in difficulty for the range of lengths used in this experiment, as indicated by the score per cul-de-sac for trials, is very slight especially for lengths of 6, 8, and 10 culs-de-sac.

TABLE 3

COMPARISON OF THE TOTAL NUMBER OF ERRORS MADE IN LEARNING MAZES OF UNIFORM PATTERN BUT VARYING LENGTH

$N=20$

Length	Mean	$M\ V$	V	% 4 culs-de-sac size	Score per cul de-sac
4	10 7	6 1	57	100	2 7
6	13 9	10 3	74	130	2 3
8	35 9	16 0	45	336	4 5
10	37 7	22 4	59	352	3 8

Table 3 shows the results in terms of the total number of errors made in learning the various lengths Here, again, as in the case of trials, the two shorter and the two longer patterns are of approximately equal difficulty. When the errors per cul-de-sac are considered, neither the 6-, 8-, nor 10-cul-de-sac lengths are as difficult proportionately as the 4-.

Table 4 shows the results in terms of the amount of time (seconds) required to learn the various length patterns When time is taken as an indication of the degree of difficulty of the various length patterns, the same general tendency as that for trials and errors is apparent, viz., that an increase in length of a uniform pattern (of the type used in this experiment) does not increase proportionately the difficulty of the maze These results agree in the main with those found by Warden and Hamilton, showing an inverse relationship between length of pattern and difficulty.

TABLE 4

COMPARISON OF THE TOTAL TIME REQUIRED TO LEARN MAZES OF UNIFORM PATTERN BUT VARYING LENGTH

$N=20$

Length	Mean	$M.V$	$V.$	% 4-culs-de-sac size	Score per cul-de-sac
4	231 3	95 2	.41	100	57 8
6	254 7	98 0	39	110	42 5
8	600.2	227.2	38	259	75 0
10	647 6	244 6	38	280	64 8

SUMMARY AND DISCUSSION

The one fact which seems to be clearly revealed from the results of this experiment is that an increase in the length of a maze of uniform pattern does not result in a proportionate increase in difficulty A second point of interest is that the 10-cul-de-sac length is less difficult than the 8- in terms of the score per cul-de-sac, for trials, errors, and time

In the opinion of the author, the Warner-Warden linear pattern, as a high-relief finger maze, does not present a comparable situation to that of the memorization of serial language material. In the memorizing of a list of words or nonsense syllables, each additional word or syllable to the list adds a comparable but different unit, while an additional cul-de-sac to the length of the Warner-Warden linear-pattern maze, adds the same kind of a unit and not a comparable but different unit If this interpretation is valid, then the results obtained are what one would expect, i e, an inverse relationship between length and difficulty.

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AN EXPERIMENT IN TEACHING TACTUAL READING TO SEEING SUBJECTS

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INTRODUCTION

There is a widespread belief among seeing people that blindness automatically increases the acuity of the remaining senses The ability of most blind individuals to read embossed print tactually is frequently regarded as proof of this sensory superiority Experiments tend to show, however, that the physiological sensitivity of those without sight is in no way greater than that of the visually normal and, in some instances, it may be even less (2, 3). Notwithstanding these experimental data, tactual reading is commonly regarded as an accomplishment peculiar to the blind, which a seeing individual would find very difficult, if not impossible, to achieve

Although the writer has been informed of one or two cases of tactual reading by persons with normal vision, he has not been able to check them objectively. Teachers of blind children sometimes are advised to learn tactual reading in order that they may understand better the problems of their pupils and render more effective assistance Such advice assumes, of course, that the seeing teacher can master tactual reading and that her increase in efficiency will be commensurate with the time and energy expended in learning the system It assumes, furthermore, that the learning process involved and the problems encountered by a seeing adult in mastering tactual reading are sufficiently similar to those of young blind children to enable the former to gain real insight into the difficulties of the latter.

The experiment herein described was undertaken by the writer in an attempt to answer the following questions

1. Can seeing individuals learn tactual reading sufficiently well to reach an elementary standard of proficiency, and how much time and energy are required to achieve this minimum standard?

2 What appear to be the outstanding characteristics of the processes involved in the learning of tactual reading by seeing adults as compared with those of blind children?

The Experiment

Subjects The subjects of this experiment (referred to hereafter as *R* and *G*, respectively) are two undergraduate students in Harvard College *R* is 20 years of age and is in the sophomore year, while *G* is 19 and a junior While quantitative intelligence scores are not obtainable for these two subjects, the fact that they are doing a very satisfactory grade of work in college seems a fair indication that their intellectual equipment is superior. Both young men showed keen interest in the experiment, and its success is due in large measure to their whole-hearted cooperation. Neither of them had any previous knowledge of, nor experience with, tactual reading, and both were totally ignorant of the principle of the Braille system

Procedure. The investigation was begun on October 13, 1930, and continued through December 19, 1930. During this time each subject received thirty-two 10-minute periods (or 5 hours and 20 minutes) instruction and practice in tactual reading

The subject's eyes were blindfolded with a large silk handkerchief in such a way as to distract his attention as little as possible The blindfold always was put on before the reading material was presented so that the subjects never "saw" the material which they were required to read tactually

They were allowed to use any finger or fingers for reading which they chose, the only restriction being that they adhere to a certain method once it was adopted Both subjects used the left forefinger alone for reading In the case of *R* this is not surprising since he is left-handed, but *G*, although right-handed, claimed that his left hand was "more sensitive" Occasionally, he would change to the right forefinger or middle finger, but usually reverted to the left forefinger before the examiner called his attention to the change Frequently he bent his forearm and wrist in such a way as to make the reading finger parallel with, instead of at right angles to, the line This peculiarity gradually disappeared, however, as reading skill was acquired.

Neither *R* nor *G* made any attempt to read with both hands, although they were told that many blind persons read that way

Careful records were kept of the progress of each subject These included the date of each reading lesson, the material given, the number of letters,

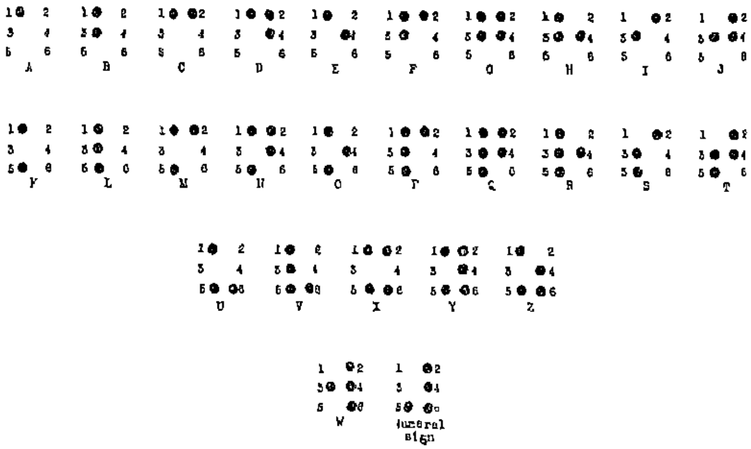

FIGURE 1
THE BRAILLE SYSTEM

words, or sentences read, and the particular difficulties encountered. Any unusual reaction or remark, also, was noted.

Before presenting further details of the experiment, it may be well to describe briefly the Braille system of tangible print which is in general use among the blind. As reference to Figure 1 will show, Braille characters are not embossed alphabetical letters, but are composed of various combinations of dots within a six-point field. This field is known as a "cell" and is three dots high and two wide. The dots are numbered in pairs from left to right so that the odd numbers, 1, 3, and 5, appear on the left side, while dots 2, 4, and 6 are on the right. It will be noted that the first ten letters (*a* to *j*) occupy only the upper half of the cell, that the next ten letters (*k* to *t*) are formed by adding dot 5 to these fundamental forms, and that the remainder of the letters (*u* to *z*) are obtained by adding dots 5 and 6. Since Braille is of French origin, *w* was missing from the original alphabet and has, therefore, been added to meet the requirements of English usage.

Punctuation marks are obtained by writing the first ten letters in the lower instead of in the upper half of the cell. Thus *a* lowered to the position of dot 3 is a comma, lower *d* is a period and lower *h* and lower *j* are open and closed quotation marks, respectively. By prefixing the numeral sign (see Figure 1) to the fundamental letters they become Arabic numerals from 1 to 0. Thus *a* prefixed by the numeral sign is 1, *d* is 4, *g* is 7, etc.

No numerals, nor contractions (word signs) were introduced into the present experiment, the aim being to keep the situation as simple as possible.

At the first reading lesson, each subject was given the first ten letters of the Braille alphabet embossed clearly on a strip of heavy paper. Each letter was named by the investigator as the subject felt it and its particular characteristics were pointed out For example, attention was called to the fact that *d* was like the upper right-hand corner of a square, *h* like the lower left-hand corner, *b* a vertical line, *c* a horizontal, and *e* and *i* diagonals in different directions The corner, line, and block characteristics (1, p 27) of the other letters from *a* to *j*, also, were pointed out but no attempt was made to have the subject recognize the letters solely by these peculiarities

The Braille letters *a* to *j* were reviewed during the first five minutes of the second reading lesson, followed by a number of words containing these letters. From this point on each subject was permitted to proceed at his own rate, but the type of material and the order of presentation were identical.

The letters *k* to *t* were given after the first ten were known. Attention was called to the fact that these were formed from the first group by the addition of another dot The subject, however, was not urged to learn them according to this logical sequence, nor was particular attention laid upon their characteristic shapes Nevertheless, both *R* and *G* associated the second line of letters with certain familiar forms. For example, *o* was called an arrowhead, *s* a sort of crescent, *t* a pair of stairs, etc (see Figure 1).

After the letters from *a* to *t* had been mastered, the final six letters of the alphabet were presented *W* was inserted in its logical place, its difference from the other characters being unnoticed Here again, the shapes of the letters seemed to be the most important factor in learning them. *V* was described as a hook or *L*-shape, *y* was a square bracket, etc (see Figure 1)

After the Braille alphabet had been learned, the reading periods were devoted to sentences and short paragraphs Punctuation and capitalization were introduced incidentally as the need arose

Practice sentences from a typewriting manual were found very useful, and short paragraphs culled from newspapers and magazines supplied reading matter of some intrinsic interest. At first, all reading material was embossed double-spaced so that no confusion in finding new lines might occur until the subjects were more familiar with tactual reading Later, however, the usual line-spacing of ordinary Braille books was introduced and caused little difficulty

Results and Their Discussion

An examination of the records shows that *R* was considerably ahead of *G* throughout the experimental period subsequent to the second lesson. The degree of this superiority is shown graphically in Figure 2.

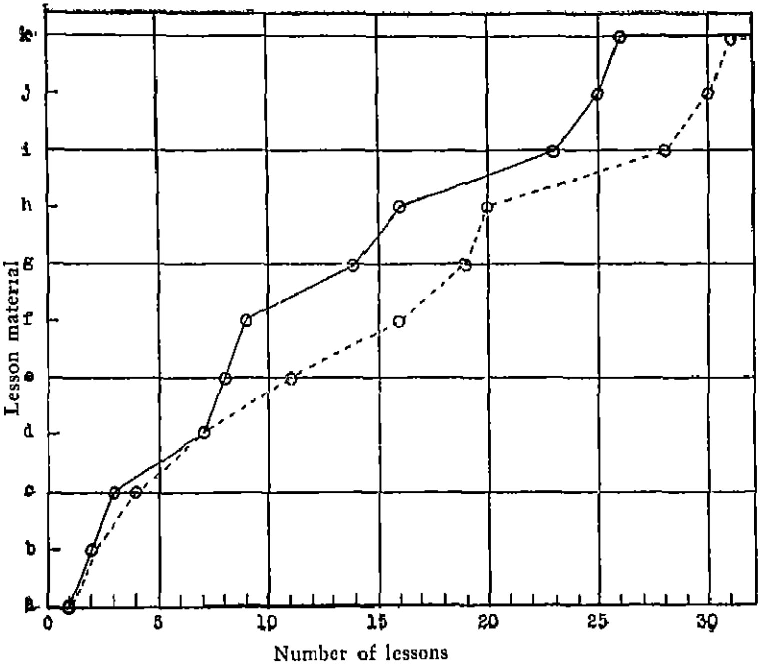

FIGURE 2

A Comparison of the Learning Curves of Two Seeing Subjects in Acquiring the Technique of Braille Reading

Solid line=Subject *R*

Broken line=Subject G

Key to lesson material *a*, letters *a* to *j* presented, *b*, words, *c*, letters *k* to *t*, *d*, sentences; *e*, letters *u* through *z*; *f*, all letters known; *g*, capital and period introduced, *h*, comma, *i*, single-spacing, *j*, quotation marks, *k*, practice reading

At the close of the experiment both subjects were tested with the Braille adaptation of the Gray Oral Reading Check Tests, Set 1, Nos 1 and 2 Test 1 was given as an ordinary reading lesson, the subject's eyes being blindfolded. The time, errors, and outstanding characteristics of the reading were recorded The blindfold was then removed, and the subject was required to read an equivalent form visually This was done to ascertain whether or not the tactual sensations produced by the Braille characters had been translated into visual images during the process of reading

The test results are shown in Table 1

Despite the fact that *R*'s performance was distinctly superior to that of

TABLE 1

	R		*G*	
	Time (sec)	Errors	Time (sec)	Errors
Test 1	472	2	435	2
Test 2	180	3	131	2
Norms for blind children in Grade I	135	5		

G during the experimental period, the latter did much better on both the final tests. The writer is inclined to believe that *R* is a better tactual reader than *G*, but that for some unknown reason *G* excelled him in a test situation. Both subjects, however, failed (in Test 1) to reach the average achievement of blind children in the first grade.

The pronounced up-and-down finger movements exhibited by both subjects throughout the learning process and in the final test probably may be partially accounted for by the fact that neither of them advanced beyond the point where they read by the letter method. *R* did comprehend a few short words like *and*, *the*, etc., as wholes, but *G* always spelled out even the simplest words. Burklen, in his discussion of synthetic and analytic touch, points out that touch movements appear to be most pronounced when the finger-reader cannot recognize a word as a whole but is obliged to analyze it into its component letters (1, p. 36). A skilled word and context reader can glide smoothly along the line making very few up-and-down or regressive movements.

The fact that both *R* and *G* were able to read Braille with their eyes even better than with their fingers seems to indicate definitely that all their tactual sensations of the Braille characters were translated into visual images. This changing of tactual sensations into visual images obviously makes the learning of tactual reading by a seeing adult quite different from that of a congenitally blind child, or one whose sight was lost at so early an age that his visual imagery has practically disappeared. In view of this fundamental difference, it seems rather doubtful if the seeing teacher of blind children can increase her understanding of their reading problems by learning tactual reading herself.

It seems highly probable, also, that most newly-blinded adults employ visual imagery in learning tactual reading and that they generally adhere to the letter, rather than to the word, method. This may, perhaps, account for the fact that such adults seldom become fluent Braille readers, because the process of analysis and visualization makes reading much slower. This is contrary to the popular belief that the sense of touch of adults is duller than that of children.

As our test results show, the subjects in this experiment failed to achieve first-grade reading ability after nearly five hours and a half of intensive individual instruction. It is reasonable to suppose that a seeing adult

would take much longer if self-instruction was his only means of learning finger-reading *It may be doubted, therefore, in consideration of the differences* between the learning of Braille by seeing adults and blind children, already pointed out, whether a seeing teacher should be expected to master the mechanics of tactual reading

Conclusions

It is unfortunate that the small number of subjects included in the investigation preclude any sweeping generalizations It is believed, however, that enough data have been obtained to indicate what may reasonably be expected of seeing adults as to the mastering of finger-reading, using the method described, for

1 After nearly five and a half hours of distributed, intensive, individual instruction, two superior college students with normal vision failed to reach first-grade standards in tactual reading.

2. The subjects of this experiment obviously interpreted their tactual sensations into visual images, making their reading processes quite different from that of blind children.

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BOOKS

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BARBARA S BURKS, D W JENSEN, & LEWIS M TERMAN. Genetic studies of *Genius Vol 3 The promise of youth, follow-up studies of a thousand gifted children* Stanford University, Calif Stanford Univ Press, 1930 Pp. xiv+508. $6 00.

It is not often that an investigator steadily develops a well-defined research over a period of twenty-five years. Terman published, as a student, "A Preliminary Study in the Psychology and Pedagogy of Leadership," in the *Pedagogical Seminary*, for 1904 In 1930, appeared the volume here to be considered During the intervening years, Terman has constantly studied superior children, has refined and devised methods of approach to their psychology, and has given to education a large sum of established fact which before his day did not exist, and which will probably be of increasing importance for the social economy of the future.

The third volume of "Genetic Studies of Genius" consists of four parts Part I is a statistical study of the subsequent history of gifted children, first studied six years earlier. Part II contains case studies of individuals, following the clinical method. Part III is a study of the literary productions of gifted juvenile authors Part IV embodies a summary of the total material presented, with tentative forecasts. An appendix presents copies of the blanks used for the follow-up.

In Part I, the following aspects of subsequent development are studied: Status on intelligence tests, educational progress, scholastic achievement, interests, vocational plans and achievement, social and personal traits, home conditions, familial statistics and special abilities

Due to limitation of funds, the follow-up of the children first reported in 1925 was chiefly through correspondence. This is, of course, regretted by all, especially by the investigator and his co-workers The ideal of the investigator was to re-establish at intervals personal contact with each child, and to secure for each sufficiently detailed information for a case study. This ideal could be only approximated

The returns from the questionnaire sent by mail to the nearly 1500 subjects in the Stanford files yield a mass of important data The percentage

of returns from the 643 children in the main or "regular" group was high enough (96 7%) to insure avoidance of the fallacies of selection

From these questionnaires the chief results were, briefly, as follows In the present study, 74 per cent of the boys and 83 per cent of the girls are accelerated in age-grade status, as compared with 67 per cent of the total group six years previously. Age of graduation from the eighth grade was typically for boys about 13-1 and for girls 12-10, from senior high school, *for boys about 16-10, and for girls about 16-8. About 95 per cent of the* gifted desire to go to college, but only about 80 per cent can plan to go.

Parents' ratings of attitude toward school or college show some decrease in "desirable attitudes," though a large majority of both sexes still show *good attitudes Transcripts of a limited number of high-school records* establish that the gifted receive "A" grades four to eight times as often as do unselected pupils (who are older) in the same studies Girls receive higher average marks than do boys in every high-school course, including *mathematics and science, where the boys do better on standardized tests.*

From those whose college careers can now be studied, it is shown how highly selected for intelligence are Stanford students, inasmuch as the gifted group has not much advantage in scholarship over the freshmen as a body (*though it must be borne in mind that the former are younger*). Among the gifted who have graduated from college, a much greater than chance proportion of Phi Beta Kappa elections was achieved

As adolescents, the gifted take part in a wide variety of extra-curricular activities, and attain to a large number of offices and honors This is in accord with Lamson's study of young gifted children in the senior high schools of New York

Questionnaire methods of exploring personality reveal that gifted boys are about as "masculine" as are the generality of boys, while gifted girls are reliably less "feminine" than girls in general are The gifted show an increasingly great tendency to prefer companions older than themselves Those who test above 170 IQ have considerably more difficulty in social adjustment than do those nearer 140 IQ. The great majority of the gifted are reported as responding well to discipline, both at home and at school The great majority are reported, also, as having good health Of the 643 original subjects, 5 died in the interval elapsed, one of these having committed suicide

During the six-year interval the occupational status of the fathers increased from 12 8 to 13.3 (Barr rating) Of mothers employed outside the home, 43 per cent were in the professional category, and nearly all of the rest were in semi-professional work or in business The mean IQ of 130 siblings of the "regular" group is 123

Data for the "special ability group" suggest that "without the support of high intelligence, special talent is not likely to mature into achievements of very unusual merit" A small number of cases were visited personally, and

were retested by field-workers with individual tests The limitation of this work is that there exists no standardized test, either of intelligence or of scholastic achievement, that will correctly distribute highly intelligent adolescents in relation to the generality Stanford-Binet breaks down at about 11 years of age, for children in the highest ranges, and attempts at "correction" are, to say the least, speculative. The same considerations hold for group tests We have no test at present available that will adequately distribute gifted persons who are more than 12 years old, in terms of the generality The nearest approximation to such a test is still the old Army Alpha, which was not used in the present investigation.

Using Stanford-Binet, Herring-Binet, Terman Group Tests, and the Thorndike Test for College Entrants, the following results were obtained on samples of the original group The "corrected" IQ's on Stanford-Binet showed a drop of 3 points for boys, and of 13 points for girls, on the average Gifted boys surpassed gifted girls on the Terman Group Test at nearly every level Retests by means of Herring-Binet showed marked decreases in IQ in both sexes, as would be expected from the fact that Herring-Binet is invalid for young children, as well as for older children, above 130 IQ Some subjects showed a drop of 15 points or more in IQ, but for the group as a whole, a high status is maintained On the Stanford Achievement Test, the EQ shows a drop, as would be expected, since the brightest "break" this test at 13 years of age.

The data contained in Part I must be considered very valuable, though falling short of finality for two reasons (1) the data derived were not gathered also for the original controls, so that comparative statements are lacking where needed, (2) the mental tests used will not distribute gifted adolescents in relation to the generality

Part II is full of interest for the study of individuality Case studies are here made, illustrative of various conditions under which the gifted child is found These throw a light upon the subject which never comes from statistical study alone

Part III shows that the literary productions of some of the gifted now among us are rated by competent critics as equal to the juvenile productions of persons who have achieved eminence in literature Girls far outranked boys in the quality of these productions. An item of incidental interest to educators is publication of the IQ range of the pupils who contributed to the work published in Mearns' *Creative Youth*. These pupils were of very superior intelligence.

Part IV is one of the most valuable portions of the book, containing Terman's reflections on the total knowledge emerging from a quarter of a century of research. In the present renaissance of child-study, much research is being "done" by persons who never themselves come into contact with children, who investigate and write largely or wholly through "ghosts," and who would scarcely know how to go about the task of eliciting a fact

of child psychology if personally confronted with children. Terman's work has, by contrast, the authentic quality of one who has had genuine experience with hundreds of children In recent years he, too, has worked largely through excellent assistants, but not until he had himself gained mastery The result is a degree of insight and a wealth of suggestion, which can be appreciated only by first-hand study of the book itself The student who is interested in any work that deals with people will—one almost says must—read these reflections and forecasts for himself

Probably no other equal sum of money, granted for psychological research, has bought more for education than has been bought by the $60,000 which supported the three volumes of *Genetic Studies of Genius* Terman says, "it would be ill grace to dwell upon the fact that more could have been accomplished if larger funds had been available."

There is, however, nothing to prevent the reviewer from looking the gift-horse in the mouth, and from concluding that the millions of dollars given in recent years to study the stupid and vicious compare unfavorably for human welfare with this sum, given to study the gifted.

It is suggested repeatedly by the facts emerging from this volume that one of the most promising and interesting of all social experiments would be the endowment for life, of several young children identified, tested, and appraised according to modern methods. The endowment of gifted individuals does not appeal to American philanthropy. Giving is inclined toward the least improvable members of society, on the one hand, and to institutions and projects on the other. There is thus neither inclination nor patience to trouble with the experimental endowment of gifted individuals Nevertheless, this should be urged The outcome would, of course, be unpredictable since it would be something new under the sun, but *something* of value for social science and education would surely come of it

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SUSAN ISAACS *Intellectual Growth in Young Children.* New York Harcourt, Brace, 1930 Pp xi+370 $4 00

This is the first of a series of three volumes called the *Behavior of Young Children,* which is evidently intended to be the definitive statement of the procedures and findings of the Malting House School experiment of 1924-1927 The second volume will deal with social development in young children, and the third with individual histories Mrs. Isaacs realizes, of course (her whole point of view would demand that she realize it), the essential impossibility of making any natural division between intellectual and social developments; nevertheless the material stressed in the volume

on the former is that ordinarily described as cognition or reasoning, while the second volume is to deal with matters of fantasy, motive, unconscious material, and the consequences of these in interindividual relations

It is difficult to evaluate the significance of the Malting House School experiment in the social scene It appears to have owed its inception to a combination of a group of extraordinarily intelligent parents and a sympathetic philanthropist, to what it owed its cessation we are not told Its advertisement of about 1927 soliciting the services of an individual from anywhere in the world competent to inculcate the scientific spirit in young children was received with a curious combination of apathy and enthusiasm It is this same combination of attitudes with respect to the experiment as a whole which baffles confident evaluation Extending the universe of discourse somewhat, it appears to be comparable to the attitude regarding progressive education, and perhaps even of all education It would probably be a salutary and chastening exercise of the social-psychoanalytical type to attempt to comprehend fully the degree to which adults lack any vital interest in the welfare of children; or possibly the degree to which all of us lack interest in the welfare of anyone other than those to whom we have an immediate and emotionalized personal attachment.

Returning from the basic to the more visible motivations of the attitudes toward progressive education in general, and the Malting House School experiment in particular, two opposed possibilities present themselves: it may be that traditional attitudes regarding children and the techniques of their culture are so firmly fixed by habit and early conditioning that only the exceptional individual, even in intelligent groups, makes any real mental contact with what the new education is all about On this supposition the apathy is that of a dog to a telephone—not enough of its significance penetrates to awaken any reaction at all. The reverse and more optimistic hypothesis is that among intelligent groups theory and practice in child training are in process of moving on past the pioneers—a phenomenon similar to that by which Ibsen has become a little dull by reason of emphasis on what we have now come to consider inherently obvious

The reviewer has no idea which of these hypotheses is to be preferred It appears to him that the present is undoubtedly a quiet period in the development of progressive education, but the quietness may be due to the inevitable following of a phase of hard work and consolidation of territory upon the earlier pioneer phase of philosophies, principles, and propaganda

The present book opens with a consideration of records in the study of children's behavior It is freely admitted that the records are qualitative and uncontrolled, and that their collection was secondary to the more pressing business of education However, it is maintained that they are as free as possible from interpretation, i e., the opinions and evaluations of Mrs Isaacs, while present, are kept so far as possible apart from the objective records The peculiar value of these materials as compared with those

usually taken under similar conditions is of course the ruling out of the ethical point of view, or at least its reduction to the lowest terms consistent with the continuation of the experiment. In this connection contrasts are drawn with the work of Stern, and the author's earlier statement on the function of the school for young children is re-presented and elaborated The second chapter gives the conditions of observations, including the set-up, the limits and negative conditions of activity (chiefly those imposed by the necessity for physical safety), and the positive stimuli to activity, consisting of the large assortment of materials and a sympathetic and encouraging attitude toward their use on the part of the adults present. Chapter 3 presents the theoretical analysis of the material on discovery, *reasoning, and thought* *This is organized into (1) applications of knowledge*, (2) increase of knowledge, (3) interchange of knowledge, and (4) miscellaneous Examples sufficient for illustration are given The author takes the view that maturation should be looked upon as a limiting concept, and confined to the aspects of growth which can be shown to be a function of *experience*. On this point the author differs with Piaget, who, however, she realizes has made one of the most important recent contributions to child psychology. She holds that his use of the maturation concept, resulting in a structural interpretation of the developing mind, is not critically enough used Mrs. Isaacs would seem to have the better of the argument, Piaget's researches appear to have been carried on under the preconception that a structure would be found, and largely to have ruled out conditions necessary to demonstrate the influence of experience Our author's positive findings indicate that true reasoning is present very early, and that the incapacities noted by Piaget largely disappear when adequate experience for the formation of inferences has been obtained. This chapter also examines in detail the relation between thought and fantasy with the conclusion that, although fairly well distinguished by the child himself, they have important and continuous effects on each other A concluding note to the chapter mentions that all the children (with the exception of one neurotic child) were commented upon by the schools to which they went after the closing down of the Malting House School as remarkable for intelligence and adaptability. Chapter 4 contains a large number of illustrations from the records, fully documented as to date, age, and situation, illustrating fully the analysis of the preceding chapter Chapter 5, on biological interests, and Chapter 6, records illustrating biological interests, are an elaboration of an article published last year in the *Forum of Education* Particular attention is given to the analysis of instances of cruelty and tenderness in the same children, in which great individual differences are shown in spite of a relatively constant attitude of scientific curiosity toward animals on the part of the adult environment Chapter 7 is a group record of four sample weeks at different periods during the history of the school, ages and dates are given in full Chapter 8 is a summary of the different classes of activities, with examples, observed during the three years under consideration

Nathan Isaacs contributes a long analysis of the functions of children's "why" questions, which is reproduced as Appendix A; and a short statement (Appendix B) on the relations of education and science. Appendix C is a series of further observations on the same children reported by particularly cooperative parents. All told, the volume stands as one of the first collections of careful observational evidence tending to show the desirable effect in practice of the "child centered" theory in education; and we await the appearance of Volumes 2 and 3 of the trilogy with keen interest.

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$7.00 per volume
Single numbers $2.00

QUARTERLY

December, 1931
Volume XXXIX, No. 4

Founded by G. Stanley Hall in 1891

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Jedem Artikel wird ein Referat auf deutsch folgen

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CHARACTERISTICS AND RELATIONS OF MOTOR SPEED AND DEXTERITY AMONG YOUNG CHILDREN*

From Teachers College, Columbia University

ARTHUR I GATES AND ADELIN WHITE SCOTT

The present study, the data for which were secured in 1926, was originally planned as a companion to a similar experiment performed with older subjects by Uhrbrock (13, esp pp. 34-38, 45-54) and published in 1928 The original purpose was to ascertain the degree to which speed of response in one task correlates with the rate of reaction in other performances, with the average speed in several tasks, with intelligence, and other factors, among young adults, in one case, and among young children, from four to six years old, in the other By using similar tests and procedures in both studies, it was hoped that the results would shed some light on the general problem of whether, as some have assumed, speed of reaction is much less specialized in childhood and more closely associated with intelligence than in later years. The present study was arranged, furthermore, to provide data for an analysis of the factors which tend to produce correlations among different tests of motor speed and dexterity.

THE TESTS OF SPEED OF REACTION[1]

In the present study, the field of inquiry has been limited to a number of motor functions which were selected and tested in such a way as to reveal some of the characteristics of speed in response As subjects for the study were taken 50 young children, mainly from 4.5 to 6 years of age, from the kindergarten class of the Horace Mann School In addition to the chronological age and Stanford-Binet mental age, the ratings of four teachers on the general motor speed and skill of each pupil were secured To each of these pupils

*Accepted for publication by Carl Murchison of the Editorial Board, and received in the Editorial Office, November 14, 1930.

[1]More complete descriptions of the tests, average scores, and average deviations of the scores from the average are given in the section on "Methods of Giving and Scoring Tests of Motor Speed and Dexterity"

were given twice, once on each of two successive school days, the following 17 individual tests.

1. *Putting Marbles in a Slot: Right Hand* For this test was arranged a box with an open compartment for marbles behind which was a closed compartment with a round slot at the center. The children were instructed carefully to put the marbles, one at a time, into the hole with the *right* hand. The score is the number of marbles placed in the box *in 30 seconds*.

2. *Putting Marbles in a Slot Left Hand.* This test was identical with Test 1, except that the left hand was used

3. *Putting Marbles in a Slot: Both Hands* Same as Test 1, except that child could use both hands but could not take more than one marble in a hand at a time.

4. *Tapping Bell: Right Hand* For this test a strong classroom tap bell was fixed near the center of a board, 24 by 30 inches About 6 inches to the right of the bell was painted a cross. The task was to hit alternatively the cross and the bell as rapidly as possible. Score was the number of bell taps in *10 seconds*.

5 *Tapping Bell. Left Hand.* Same as Test 4, except the cross is placed on the left of the bell and the tapping was done with the left hand.

6 *Tapping Bell Hands Alternating* Same apparatus as in Test 4, with a cross on both sides of the bell. The child struck the bell with one hand after the other.

7. *Tapping Bell: Right Index Finger Only.*

8. *Tapping Bell: Left Index Finger Only.*

9 *Tapping Bell: Fingers Alternating*

10. *Tapping Bell: Right Foot* In this test the subject stood on the board on one foot while tapping the bell with the other

11. *Tapping Bell: Left Foot*

12 *Tapping Bell: Feet Alternating*

13. *Sorting Cards: Right Hand* A long shallow box divided into five compartments is placed in front of the subject. From a pile of cards of five different colors, which the subject holds on the table directly before him with the left hand, the cards are placed, one at a time, in the proper box The score is the number of cards correctly placed in 30 seconds.

14. *Sorting Cards: Left Hand.* The pack of cards is held with the right hand and placed with the left.

15. *Repetition of Syllables.* The subject is instructed and given some preliminary practice in saying "Baa, baa, Black Sheep" as fast as he can. The score is number of syllables spoken correctly in 10 seconds

16 *Punching Holes Right Hand* Between two thin, perforated boards, 10½ x 13 inches, a piece of paper is placed. The pupil is instructed to push a pencil into the holes, following the rows from left to right, as rapidly as possible The board contains 11 rows of 8 holes each. The time is 30 seconds; the score is determined by counting the holes punched in the paper.

17 *Punching Holes Left Hand*

The tests described above, which were selected from a much larger number that were tried out, proved to be satisfactory in most respects They were readily understood and enjoyed by the pupils; they were neither too hard nor easy, and therefore gave a satisfactory distribution of scores, they could be scored with ease and with slight chance for error; they demanded performances at a constant, or nearly constant, level of quality or accuracy

Since each pupil took each test on two successive school days, the reliability coefficients could be secured by correlating the first and second scores for the group of 50 These self-correlations are given in Table 1. For computing the correlations of the tests with each other and with other variables, the records for the two trials of each test were combined in order to provide a more reliable measure of each skill. The reliabilities of these combined measurements, or the correlations of the combination of two tests with two similar tests of the same functions, may be predicted approximately by the Spearman-Brown formula

$$r_x = \frac{Nr}{1 + (N-1)r}$$

The self-correlations obtained by this method, which will be later compared with the intercorrelations, are also given in Table 1.

Correlations of the Motor-Speed Tests with Intelligence Tests

The combined scores of the two tests of each type of motor-speed, the Stanford-Binet mental age and chronological age were correlated with each other in order to make it possible to eliminate the influence of age upon the association of various types of speed with intelligence Table 2 gives the resulting partial correlations

TABLE 1

CORRELATIONS OF THE FIRST WITH THE SECOND TRIAL IN EACH OF 17 TESTS OF SPEED OF REACTION (COLUMN 1) AND CORRELATIONS BETWEEN TWO SUCH TRIALS AND TWO OTHERS, ACCORDING TO THE SPEARMAN-BROWN FORMULA (COLUMN 2)

		1	2
1	Putting marbles in box, right hand	654	.80
2.	Putting marbles in box, left hand	640	.78
3	Putting marbles in box, both hands	612	76
4	Clapping bell, right hand	745	85
5	Clapping bell, left hand	826	91
6	Clapping bell, alternate hand	.513	68
7.	Tapping bell, right finger	.731	83
8	Tapping bell, left finger	672	80
9	Tapping bell, alternate finger	468	.66
10.	Tapping bell, right foot	741	.84
11	Tapping bell, left foot	556	.71
12.	Tapping bell, alternate foot	585	.74
13	Sorting cards, right hand	627	.77
14	Sorting cards, left hand	613	76
15	Repetition of syllables	.516	68
16.	Punching holes, right hand	.391	56
17.	Punching holes, left hand	651	.80

The coefficients of motor-speed and intelligence, with age eliminated by partial correlations, range from .10 to .36; the average is .24. The "composite score," made by summing the scores of all 17 tests, gives a coefficient of .29 with intelligence, when age is rendered constant. The averages of the ratings of four teachers on the motor-speed of each child correlates .26, a figure midway between the average of the individual coefficients and the correlation of the composite motor-speed score with intelligence

These figures agree, in a general way, with most of those obtained

TABLE 2

PARTIAL CORRELATIONS OF MOTOR-SPEED TESTS 1 TO 17, INCLUSIVE, AND STANFORD-BINET MENTAL AGE, WITH CHRONOLOGICAL AGE ELIMINATED

(The numbers 1 to 17 correspond to the descriptions of the test given above)

Test	Partial r	Test	Partial r	Test	Partial r
1	24	7	32	13	34
2	20	8	.20	14	36
3	.29	9	16	15	.21
4	16	10	.18	16	31
5	.22	11	25	17	34
6	.10	12	25	Aver.	.24

in studies of the association of similar motor-speed tests and intelligence in the case of older children and adults in showing the correlation to be "positive but low." Among the correlations of these variables in the case of adults, however, are found a number of figures which are appreciably lower and a few that are zero or negative[2] According to estimates roughly made by the writer, the average of the coefficients obtained from studies of adults with similar tests and corrected for differences in range of abilities among the subjects would be +0.18 or less Thus it appears that, while motor-speed is associated with intelligence in barely perceptible degree among adults, it is positively correlated in greater, but by no means a large, degree in the case of young children.

The fact that the correlations of motor-speed and intelligence among 4½- to 6-year-old children is higher than the estimates for adults raises certain questions concerning the practice of including tests of motor ability and dexterity among the items in the Kuhlmann, the Merrill-Palmer, and other intelligence tests for young children. Although the data indicate that the simple motor-speed tests are not *very promising intelligence test items in the case of adults,* or even in the case of the five- or six-year-old children, the suggestion that the correlations become higher the younger the subjects that are tested may afford a promise, if not satisfactory evidence, that motor functions are fair indications of intellect in infancy Indeed, Gesell's series of tests, designed to appraise the "developmental status" of infants, includes a substantial number of examinations based upon motor performances. While Gesell recognizes specialization and does not call his scale an intelligence test, casual readers may get the impression that the "developmental quotients" based upon his battery are similar in significance to intelligence quotients.[3] But, before the present data are taken as evidence in support of this assumption, several considerations should be viewed.

It should be repeated that the correlation of .18 or lower, given as the estimated average of results from various studies of adult subjects, is extremely unreliable It is really well-nigh impossible to summarize these miscellaneous studies, accumulated over a quarter-century, in a coefficient comparable with those obtained in the present study.

---

[2]See, for example, McCall (6) and Sisk (10), and other studies summarized in the latter report

[3]See, for example, Gesell (4, pp 142-163, 187-189, etc)

It has been suggested, moreover, that the correlations of motor-speed performances and intelligence increase as the motor-speed tasks vary from very simple to more complex.[1] Thus the correlation of intelligence and speed of operating a complex machine or implement is higher than the correlation of intelligence and simple tapping with the finger. It is possible, furthermore, that a given task which is very simple to the adult is quite complex for a young child. It is possible, in other words, that the tests used in the present study with children under six represent a group of more complex activities than those used with adults—hence the higher correlations in the former case

To secure some indication of the validity of this view, six judges were asked to rate the 17 performances, in order, from the most to the least simple for the children. These ratings gave a rank correlation of approximately .80 with the magnitudes of the coefficients of the tests and intelligence Among these children, in other words, the more complex the act, the higher the correlation with intelligence

The same six judges were also asked to arrange the tests in order from the ones requiring the most "intelligence, understanding, or mental alertness" to affect "adjustment to the task" or "understanding of the test situation and procedure" to those requiring the least degree of such intellectual insight. For these judgments, the 17 tests were grouped under seven types of tasks. They are given in Table 3 in the order, as judged, from the one requiring most to the one requiring the least mental adjustment, accompanied by the average correlation of the tests of each type and intelligence.

It is apparent that the rankings of the tasks on the basis of intellectual adaptation to the performance conditions and the correlations of the tasks with mental age are substantially identical The implication, therefore, is that a motor-speed test which is a simple motor task for adults may require of a young child the exercise of some degree of intelligence to achieve effective adjustment to the task. To that degree, the motor task becomes an intellectual problem and consequently shows a positive correlation with intelligence The more complex tasks used in the present study were, in other words, in some measure intelligence tests of the type usually termed "performance tests" and not merely tests of motor-speed pure and simple

[1]See, for example, Sisk (10)

TABLE 3

RANKING OF SEVEN TYPES OF MOTOR TESTS ACCORDING TO ESTIMATED DEGREE OF INTELLECTUAL ADAPTATION TO THE EXPERIMENTAL CONDITIONS AND THE CORRELATIONS OF THE TESTS WITH MENTAL AGE

Rank	Task	r with intelligence
1	Sorting cards	.35
2	Punching holes	.33
3	Putting marbles in box	.24
4	*Tapping with foot*	.227
5	Tapping with hand	.227
6	Repeating syllables	.21
7	Clapping bell	.19

A glance at Table 3 reveals the fact that, as the task makes a smaller demand upon the child's intelligence to understand and adjust himself effectively to the performance situation, the correlations of the scores with mental age become smaller. Indeed, the task judged to make the least demand upon intelligence shows a coefficient with mental age of .19. If this task is taken as the nearest approach to a test of motor-speed, pure and simple, it may be said that motor speed and intelligence are nearly, if not quite, as unrelated among young children as among older children and adults. This implies, but of course it does not prove, that intelligence and motor dexterity are as nearly specific and unrelated during earliest infancy as later. It implies that, from birth onward, motor dexterity *in and of itself* indicates intelligence in scarcely appreciable degree. The correlation found between these variables is merely that inexplicable and nearly trifling tendency of "desirable" traits to go together. Motor dexterity, in and of itself, seems to be correlated with intelligence little or no more than height or physical beauty. These are, to repeat, merely suggestions implied in the data and not facts proved to demonstration. The facts remain to be discovered by more extensive and crucial investigations especially with infants and young children, as well as adults, as subjects. It seems important that the facts be known before scales based upon a wide variety of motor and mental functions as are found in the Gesell, Kuhlmann, Merrill-Palmer, Buhler, and other series of tests for infants become widely interpreted as intelligence tests.

Correlations of Various Measures of Motor Speed with Each Other and a Composite Score

The next problem is that of determining the degree to which one

measure of motor speed indicates a child's status in other types of motor speed and in the best available composite score of average or general motor speed or dexterity. Consider first the intercorrelations of the scores of the 17 tests. As stated above, the score for each test is the sum of the scores for two trials at an interval of 24 hours. These intercorrelations are given in Table 4

In Table 4 may be found a considerable range in the size of the intercorrelations of the 17 speed tests. Various factors, which we shall presently attempt to identify and gauge, determine the magnitude of these coefficients. A general indication of how well a person's relative position shown in one test is likely to be similar to his position in other tests is given by the average of the 136 intercorrelations found between tests 1 to 17 in Table 4. This average coefficient is .418. The figure is significant when compared to the average of the 17 self-correlations, which is .76 (see Table 1). The typical or average test, then, predicts a second measurement of speed in the same activity to the extent of $r = 0.76$, whereas it predicts speed in another activity only to the extent of $r = 0.418$ The difference between these coefficients is really very great The implication is that, among such activities as were here tested (and most of them appear to be rather similar), a person's speed is not everywhere about equally high, average, or low in comparison with others On the contrary, there is much specialization.

Many of the intercorrelations in this table are very low If allowances are made for the fact that variations in chronological and mental ages tend to make the coefficients spuriously high, it will be apparent that motor dexterity, in itself, is decidedly specialized. This will be notably true if only the intercorrelations of the seven *types* of activities, and not the intercorrelations of tests of one type, e.g., tapping with right hand, left hand, or with right hand and left hand alternately, are considered This fact will be made clear in a later section, in which these intercorrelations will be more thoroughly analyzed.

The practical problem of determining to what extent average or general speed of motor reaction is revealed by one or more individual tests may be approached by computing the correlation of individual tests with a composite score made by combining all of the 17 tests, or all of them except the test being correlated with the composite Since in this case the absolute magnitude of the coefficient should be

INTERCORRELATIONS OF T

	Test	1	2	3	4
1	Marbles in box, R.H		83	49	50
2	Marbles in box, L H.	83		41	37
3	Marbles in box, both	.49	.41		46
4	Clap bell, R H	50	37	46	
5	Clap bell, L H.	47	35	45	78
6	Clap bell, alt	23	03	27	42
7	Tap bell, R. fin	61	.46	40	70
8	Tap bell, L fin	52	36	32	61
9	*Tap bell, alt*	49	.43	.35	.53
10.	Tap bell, R foot	.56	44	25	70
11	Tap bell, L foot	44	32	15	58
12	Tap bell, alt	47	39	37	56
13	Sort cards, R.H	58	54	50	35
14	Sort cards, L H	54	.58	23	30
15	Rep syllables	19	10	.10	.17
16	Punch holes, R H.	67	62	27	38
17	Punch holes, L H	65	.66	32	48

HE 17 TESTS OF MOTOR SPEED

5	6	7	8	9	10	11	12	13	14	15	16	17
47	23	61	.52	49	56	.44	.47	58	54	19	67	65
35	03	.46	36	43	.44	32	39	54	58	10	62	66
45	27	40	32	35	25	15	37	50	23	10	27	32
78	42	70	61	53	.70	.58	56	35	30	17	38	48
	50	71	68	64	69	.71	58	38	.33	25	32	60
.50		39	35	45	.39	41	39	15	09	16	.09	.12
71	39		76	56	61	58	58	43	43	04	36	.49
68	.35	76		67	68	.70	45	28	28	01	30	46
64	45	56	.67		57	54	55	28	29	09	24	41
69	39	61	68	57		79	63	20	21	04	51	58
71	41	58	70	54	79		56	24	34	.02	36	55
58	39	58	45	55	.63	56		23	25	09	44	57
38	15	43	28	28	20	.24	.23		64	12	43	41
33	09	43	28	29	21	34	25	64		22	38	37
.25	16	04	.01	09	04	02	09	12	22		17	32
.32	09	36	30	24	51	36	.44	.43	38	17		74
60	.12	.49	46	41	58	55	57	.41	37	32	74	

TABLE 5

PARTIAL CORRELATIONS OF THE TESTS WITH (A) A COMPOSITE OF ALL 17 TESTS AND (B) A COMPOSITE OF ALL TESTS EXCEPT THE ONE CORRELATED WITH IT, WITH AGE ELIMINATED IN BOTH CASES

Test	Comp A	Comp. B	Test	Comp A	Comp. B
1	63	53	10	55	44
2	64	54	11	.56	47
3	.66	56	12	63	53
4	66	55	13	63	52
5	65	.55	14	64	55
6	61	52	15	50	41
7	65	55	16	54	.44
8	63	.53	17	53	42
9	65	54	Aver	61	51

considered, it is advisable to eliminate the influence of chronological age which tends to increase the correlation. The correlations of the individual tests and the composite scores with age eliminated are given in Table 5.

The more significant figure is the coefficient of a test with Composite B, since the presence of the score of the test itself in Composite A increases the coefficient spuriously. The average correlation of a single test with a composite of the other 16 tests is .51 Since many of these tests are dependent in some degree upon intelligence, as we observed above, this factor may also be eliminated. The resulting partial correlation is approximately .475. An average single test of speed, then, yields a moderate, positive correlation with a battery of 16 other tests

A few multiple correlations may be given to indicate approximately the rate at which the correlation with a composite of the remaining tests is increased by teaming together more than one test

$$R1 \text{ (composite)} = 50$$
$$R1 + 14 \text{ (composite)} = .67$$
$$R1 + 14 + 11 \text{ (composite)} = 73$$
$$R1 + 14 + 11 + 4 \text{ (composite)} = 76$$

These figures are sufficient to indicate the nature of the increase of the correlations with the composite or general measure of speed of response brought about by lengthening the series of tests. The fact that motor-speed in each of the functions used in the series possesses a considerable degree of independence from others means that one test can be only a fair indication of average motor dexterity,

two are better than one; three are better than two; and so on But a perfect measure of the average speed of performance can be obtained only by measuring and combining every performance entering into the average While it is conceivable that such a composite measure of "average" or "general" speed of reaction may have practical value, it is more probable that, for practical purposes, the most useful thing to do is to determine a person's proficiency in the particular task in which his service is contemplated. If one is interested in selecting persons to sort cards and put pegs in a board, it is better to test them for these two operations separately than to rate them for both performances on a scale of motor speed in general If a picture of "general" or average speed is desired, the correlations indicate the simple fact that the larger number of tests of different types one applies, the more reliable the resulting average will be. The only answer to give to the question, "How many tests should I give?" is "The more the better."

Correlation of the Tests and Teachers' Judgments

Four teachers independently rated each of the children for general, all-round motor speed and dexterity. These ratings were correlated with each of the tests The coefficients are given in Table 6

The teachers' ratings of "general motor dexterity" yield rather low correlations with speed in particular tasks. The correlation of the teachers' ratings and the composite score from the 16 tests is, of course, appreciably higher, namely, 52, or a trifle better than the correlation of a single test with 16 other tests, but not as high as the correlation of 2 tests with the remaining 15

TABLE 6

CORRELATIONS OF TEACHERS' JUDGMENTS OF MOTOR DEXTERITY AND THE 17 TESTS

Influence of age eliminated

Test	r	Test	r
1	48	10	28
2	.32	11	29
3	24	12	26
4	30	13	39
5	27	14	23
6	08	15	18
7	30	16	.35
8	20	17	27
9	16	Aver	.27

TABLE 7

CORRELATIONS OF TEACHERS' JUDGMENTS WITH SPEED

Test	Right member	Left member	Both members
Marbles	.48	32	24
Cards	.39	.23	
Holes	35	.27	
Bell—hand	.30	27	08
Bell—finger	30	.20	16
Bell—foot	.28	29	.26
Average	.35	26	185

It may be of some incidental interest to determine the types of motor reaction to which the teachers' estimates most closely correspond, and upon which, probably, their estimates are chiefly based. The coefficients in Table 6 are so scattered that no type of activity seems to have been used predominantly as a basis of judgment. When figures are assembled under *right* and *left* hands, or other organs, or *both*, a marked difference appears, as shown in Table 7. The teachers' ratings correspond most closely to the pupils' abilities demonstrated with the right hand, finger, or foot, next with left-side performances, and least with tasks in which both members are used either together or alternately. Speed of handling marbles, sorting cards, and punching holes with the *right* hand are most closely correlated with the teachers' ratings. This result may be explained, perhaps, by assuming that these are functions of the type that are most interesting and important in kindergarten affairs and hence are more closely and frequently observed.

An Analysis of the Factors Contributing to the Correlations Among Different Tests of Motor Speed

Now that some of the general relations of motor speed and intelligence and of single tests to composites of a number of tests have been viewed, we may attempt a more detailed analysis of the correlations of different tests of motor responses in an effort to ascertain the factors which result in low correlations among some, and higher ones among others. Some light is thrown upon the nature of the sources of correlation by grouping the tests which are alike in one or more of three respects

1. *In the type of activity or performance.* For example, Tests 1, 2, and 3 are alike in that the activity is the sorting of the same deck of cards into the same receptor. They differ from other activities, such as clapping a bell or punching holes.

2 *In the bodily organs, or members, or mechanisms engaged.* For example, Tests 1, 2, and 3 are like 13 and 14 in that all of them are activities executed with the *hand,* whereas they are unlike Tests 7, 8, and 9, which are done with a *single finger,* and 10, 11, 12, which are performed with the *foot,* in this respect.

3 *In the side of the body in which the organ is.* Test 1 is like Test 4 in this respect. Both are done with mechanisms on the same (right) side of the body, whereas Test 1 differs from Test 2 since the former uses the *right* and the latter the *left* hand.

The 136 coefficients printed in Table 4 may be variously arranged to produce groups in which the tests differ in all three respects, or in any two or any one of these respects.

Consider first the performances in which the activity, the bodily organ, and the body side are different. In Table 8 are 22 correlations between such performances. The average of these coefficients is 0 269 Due partly to the fact that all of the individual tests are associated to some extent with chronological age and mental age, this correlation is spuriously high. When these factors are removed by partial correlation, the residual coefficient is approximately 0 17. This figure indicates that, among different types of motor activities done with different bodily organs on different body sides, relative speed may vary greatly. In fact, the average correlation of speed in different performances is no greater than the average correlation of speed in a motor function and intelligence[5] Among young children, in other words, speed in certain performances indicates only to a very slight extent the relative rate in performance in which different activities and bodily organs are engaged

In Tables 10 to 15, which follow, are given the correlations of various performances in which one (or more) of the factors—the type of activity, the bodily organ, and the body side—is (are) the

[5]See Table 2

TABLE 8

CORRELATIONS BETWEEN TESTS IN WHICH ACTIVITIES, MEMBERS, AND SIDES ARE DIFFERENT

Marbles, right hand—bell, left finger	52
Marbles, right hand—bell, left foot	.44
Marbles, right hand—repetition of syllables	19
Marbles, left hand—bell, right finger	46
Marbles, left hand—bell, right foot	44
Marbles, left hand—repetition of syllables	10
Bell, right finger—cards, left hand	43
Bell, right finger—holes, left hand	43
Bell, right finger—repetition of syllables	04
Bell, left finger—cards, right hand	28
Bell, left finger—holes, right hand	30
Bell, left finger—repetition of syllables	01
Bell, right foot—cards, left hand	21
Bell, right foot—holes, left hand	.58
Bell, right foot—repetition of syllables	04
Bell, left foot—cards, right hand	24
Bell, left foot—holes, right hand	.36
Bell, left foot—repetition of syllables	02
Cards, right hand—repetition of syllables	.12
Cards, left hand—repetition of syllables	22
Holes, right hand—repetition of syllables	17
Holes, left hand—repetition of syllables	32
Average	269

TABLE 9

AVERAGE CORRELATIONS COMPUTED FROM THE GROUP SHOWN IN TABLES 10 TO 15, INCLUSIVE

1	Average r of speed of performance when the activity, the bodily organ, and body side are different	.269
2.	Average r of speed of performances when the body side is the same but the activities and bodily organs are different	415
3.	Average r of speed of performances when the organ is the same but the activities and body side are different	.455
4.	Average r of speed of performance when the organ and body side are the same but the activities are different	.483
5.	Average r of speed of performance when the activity is the same but the body side and bodily organs are different	641
6	Average r of speed of performance when the activity and the body side are the same but the bodily organs are different	683
7.	Average r of speed of performance when the activity and bodily organs are the same but the body side different	.757
8.	Average r of speed of performance when the activity, body side, and members are all the same	761

TABLE 10

CORRELATIONS OF PERFORMANCE IN WHICH THE ACTIVITIES AND BODILY ORGANS ARE DIFFERENT BUT THE BODY SIDE IS THE SAME

Marbles, right hand—bell, right finger	61
Marbles, right hand—bell, right foot	56
Marbles, left hand—bell, left finger	36
Marbles, left hand—bell, left foot	.32
Bell, right finger—card, right hand	43
Bell, right finger—holes, right hand	36
Bell, left finger—card, left hand	28
Bell, left finger—holes, left hand	46
Bell, right foot—card, right hand	20
Bell, right foot—holes, right hand	51
Bell, left foot—card, left hand	.34
Bell, left foot—holes, left hand	55
Average	415

TABLE 11

CORRELATIONS OF PERFORMANCES IN WHICH ACTIVITIES AND BODY SIDE ARE DIFFERENT BUT BODILY ORGANS ARE THE SAME

Marbles, right hand—bell, left hand	47
Marbles, right hand—cards, left hand	54
Marbles, right hand—holes, left hand	65
Marbles, left hand—bell, right hand	37
Marbles, left hand—cards, right hand	.54
Marbles, left hand—holes, right hand	.62
Bell, right hand—card, left hand	.30
Bell, right hand—holes, left hand	.48
Bell, left hand—card, right hand	38
Bell, left hand—holes, right hand	32
Card, right hand—holes, left hand	41
Card, left hand—holes, right hand	38
Average	455

TABLE 12

CORRELATIONS AMONG PERFORMANCES IN WHICH THE BODY SIDE AND BODILY ORGANS ARE DIFFERENT BUT THE ACTIVITY IS THE SAME

Bell, right hand—bell, left finger	61
Bell, right hand—bell, left foot	58
Bell, left hand—bell, right finger	71
Bell, left hand—bell, right foot	69
Bell, right finger—bell, left foot	58
Bell, left finger—bell, right foot	68
Average	641

TABLE 13

CORRELATIONS AMONG PERFORMANCES IN WHICH ACTIVITIES ARE DIFFERENT BUT BODILY ORGANS AND BODY SIDE ARE THE SAME

Marbles, right hand—bell, right hand	50
Marbles, right hand—cards, right hand	58
Marbles, right hand—holes, right hand	67
Marbles, left hand—bell, left hand	35
Marbles, left hand—cards, left hand	.58
Marbles, left hand—holes, left hand	.66
Bell, right hand—cards, right hand	.35
Bell, right hand—holes, right hand	38
Bell, left hand—cards, left hand	33
Bell, left hand—holes, left hand	60
Cards, right hand—holes, right hand	43
Cards, left hand—holes, left hand	.37
Average	483

TABLE 14

CORRELATIONS OF PERFORMANCE IN WHICH BODY SIDES ARE DIFFERENT BUT ACTIVITY AND BODILY ORGANS ARE THE SAME

Marbles, right hand—marbles, left hand	83
Bell, right hand—bell, left hand	.78
Bell, right finger—bell, left finger	76
Bell, right foot—bell, left foot	79
Cards, right hand—cards, left hand	.64
Holes, right hand—holes, left hand	.74
Average	*757*

same and the others different. Since it is our purpose merely to compare these correlations with each other, and since the influence of age is approximately the same, on the average, for each of these groups, the laborious task of partialing this factor out has been omitted It should be understood that all of these coefficients would be a few points lower were the age constant These following correlations should be compared with the uncorrected average of .269 (instead of the 0 17 just given), the coefficient when all three factors were different

Compared to the coefficient of 0.269 of tests in which activities, bodily organs, and body sides are all different, the correlation is higher (0.415) when the body side alone is the same. This increase is appreciable but not large

When the body side and the activity are different but the bodily

TABLE 15

Correlations of Performance in Which Bodily Organs Are Different But Activity and Body Side Are the Same

Bell, right hand—bell, right finger	70
Bell, right hand—bell, right foot	70
Bell, left hand—bell, left finger	.68
Bell, left hand—bell, left foot	.71
Bell, right finger—bell, right foot	61
Bell, left finger—bell, left foot	70
Average	683

organ is the same, the correlations of speed of performance are greater than when all these factors differ, and slightly greater than when the body side, alone, is constant If age were eliminated, this correlation would be about 0 40. This figure indicates that knowing how rapidly a child can perform with the right hand (or finger or foot) in activity *A* helps one very little to predict how rapidly, in comparison with others, the child can function with the left hand (or finger or foot) in activity *B*, so greatly is speed of movement specialized. Yet the fact remains that a person tends to maintain more nearly the same relative position in speed of various activities for the two hands or other members than in speed of various activities for different organs on the same body side

When the third factor, the type of activity, is the same and the body sides and the organs are different, the correlation becomes 0 641 This is the greatest increase made by any single factor. In fact, it is greater than the increase due to the other two factors combined, this combination producing a coefficient of 0.483. Even with age eliminated, the correlation between speed in the *same activity,* though performed with another type of bodily organ and on the opposite body side, is about 0.60, a figure which may be regarded as a fairly substantial coefficient. The nature of the activity is the greatest *single source of correlations of speed in performance* If a person is rapid in tapping the bell with his hand, he tends to be rapid, compared to others of his age, in tapping a bell with his finger or foot on either side *of the body*

Apparently, there are elements concerned with speed of performance which are common to a given type of activity, despite changes from one body side to the other and from one bodily organ to another What these elements are we shall try to discover presently

In the three groups of correlations, two factors were the same and the third was different. When body side and the type of organ are the same but the activity different, the correlation is low, 0.483. When the activity and the body side are the same but the organ different, the r is higher, 0.683. When the activity and the type of organ are the same but the body side different, the coefficient is still higher, 0.757. These figures indicate that if we know how rapidly a child can perform a given act with his right hand we can tell much better how rapidly he will perform the same act with his left hand than how rapidly he can do some other activity with the same right hand.

The facts brought out may be summarized as follows. The correlations of speed of performance are low, in fact, barely appreciable, when the type of activity, the bodily organs, and the body sides are all different. When any one, or a greater number, of these three factors is the same, the correlations become higher. Of the three factors, the influence of the body side is the least. Other things being equal, the correlations of two performances executed by members on the same right or left side of the body are not much higher than when the members are on opposite sides. The influence of the body member is greater. That is to say, the correlations are somewhat higher, other things being equal, when the same organ, such as the hand, is used in the two performances than when one organ, such as the hand, is used in one test and another, such as the foot, is used in the other. The effect of having the type of mechanism constant is not much greater than that of having the body side the same, and neither has, in absolute terms, a very marked influence. The greatest effect on correlation is produced by the type of the activity. So great is this influence that speeds of performance correlate above 0.60 when the type of activity is the same even when both of the other factors are different, that is, when two different types of organs and these on the opposite sides of the body are engaged. Such are the facts. How may they be explained?

Possible Explanation of the Influence of the Body Side

A possible explanation of the fact that, other things being equal, the correlation of speed is lowered by merely shifting the performance to the opposite body side and that it is increased by changing from two organs on opposite to two organs on the same side of the body, may be sought in the facts of individual differences in degree

of right- or left-sidedness That people are, in different degrees, superior in motor activities executed with the right (or left) members to those carried out with members on the opposite side is well known A person's position in a group, secured by a test of an organ on one side, other things being equal, would become higher or lower when the test is shifted to the other side in accordance with the degree to which his second side, compared to other individuals in his group, is better or worse than the first side tested. Concretely, if A, B, and C obtained an equal score in speed in a test of a motor act with the hand on the right side and if A were extremely right-handed, B equal-handed, and C left-handed, they would probably show differences in speed of the left members A would be slowest, and C most rapid Such shifts would, in a group, reduce correlations

Whether the degree of advantage of a member on one side over the corresponding member on the other is found to be due to differences in training or experience, to native differences in muscular or neural structure controlling the member, or, as has recently been claimed, to the differences in the function of the eyes for the two sides, would not influence this general explanation.

Explanation of the Influence of Bodily Organs

The next fact observed was that the speeds in performance of two types of bodily organs or mechanisms, other things being equal, are correlated higher when both mechanisms are of the same type, i.e., hands, than when they are different, i e, one a hand and the other a foot. This is probably due to a specialization of speed among the different organs, some persons are, compared to the average, fast of hand and slow of foot, others are fast of foot and slow of hand in various degrees in all sorts of activities If this is true, the fact that correlations are higher when the same type of mechanism is used, no matter what the activity may be, than when different types of organs are employed, would find an explanation.

How it happens that people come to be relatively more rapid in all sorts of activities conducted by one member than by others is another problem. Whether the differences are due to specialization in training or to native differences the present data do not indicate

Explanation of the Influence of the Type of Activity

It was found that the correlations of speed of performance are

very low when the activities, the body members, and the body sides are different; that they are slightly higher when either the member or the body side or both are the same, and very much higher when the type of activity is the same. There must be elements common to performance in a given activity which result in high correlations of speed, no matter with what body member or on what body side the performance is executed.

In endeavoring to ascertain, if possible, what are the elements in an activity that contribute to correlations of speed of performance, we may be assisted by getting before us a more concrete picture than the preceding analyses have provided by classifying the intercorrelations of the bell-tapping tests in which the same task and apparatus were used in six different ways with three types of body members, omitting the reactions with right and left members alternating, which presents a special problem. The intercorrelations of these performances are classified in Table 16.

In this table it is apparent that, while the factors of body side and members have some influence, there remains a substantial correlation of speed in tapping, no matter what mechanism or which side is engaged. For example, the speeds of tapping with the right hand and with the left foot, or left finger and the right foot, are correlated substantially. The average of these correlations of hands, fingers, and feet on opposite sides of the body, with the influence of age on the coefficients eliminated, would be approximately 0.60. In speed of tapping the bell, then, an individual maintains a similar relative position in a group of the same age, no matter with which organ or on which side the performance is done

Several conceivable explanations of this correlation may be offered. The association may be due to. (*a*) the common influence of intelligence in adapting to the test situation; (*b*) the common influence of different amounts of training which may affect the speed of performance of all body members in response to the bell apparatus used, or (*c*) a general, native speed in fairly simple responses of the muscles of the various members here used

The first explanation may, in a measure, be subjected to test, since speed in these performances was correlated with intelligence as measured by the Stanford-Binet test. The average correlation of the six bell-tapping tests with mental age is 0.363 This association is, however, due in considerable measure to the common factor of age

TABLE 16

INTERCORRELATIONS OF PERFORMANCES IN TAPPING A BELL IN DIFFERENT WAYS

A. Same member and side		*B. Same member, opposite sides*	
Right hand—right hand	85	Right hand—left hand	.78
Left hand—left hand	.91	Right finger—left finger	76
Right finger—right finger	.83	Right foot—left foot	.79
Left finger—left finger	80		
Right foot—right foot	84.	Average	777
Left foot—left foot	71		
Average	823		
C. Same side, different members		*D. Opposite side, different members*	
Right hand—right foot	70	Right hand—left foot	58
Left hand—left foot	.71	Left hand—right foot	69
Average	705	Average	635
Right hand—right finger	70	Right hand—left finger	61
Left hand—left finger	68	Left hand—right finger	71
Average	69	Average	66
Right finger—right foot	61	Right finger—left foot	.58
Left finger—left foot	.70	Left finger—right foot	.68
Average	655	Average	63
Average of the 6	683	Average of the 6	642

which is correlated with mental age to the extent of 0.49 and with the tests of speed to the extent (average r) of 0.395. When age is rendered constant, the correlation of speed in the tests and intelligence is approximately 0 23 This coefficient is sufficient to account for some of the correlations found among speeds of performance in a given activity by different body members.

The second explanation, namely, that training may increase the rate of tapping the bell by all body members on both body sides and that speed in all, therefore, is high or low, according to the amount or effectiveness of the training would, if correct, be a satisfactory type of explanation. It would have the support of a number of studies by Woodworth (15), Swift, (12), and others on "cross training" in which it has been found that specific practice in a given task by, say, the right hand increases efficiency of the left hand greatly (as much as 70% or more in some cases) and of the right and left feet considerably It may be noticed in Table 16 that the correlations of tapping by the right and left hands are higher than the correlations of one hand and either finger or foot. These facts are in accord with the explanation on the basis of cross training

That the effects of cross training completely account for the facts may be doubted for two reasons. First, it is not probable that the practice of the children of the same age differed very greatly, since it is improbable that any of them had practiced precisely these performances to any extent Secondly, in an experimental investigation of a similar act—tapping with a pencil for speed—with children of the same age as those used in this study, it was found that intensive daily training over a period of six months produced an improvement that was small in comparison with the differences between the individuals before and after. Every indication was that the great differences in speed of tapping were due largely to native factors.[6] While the activities in the present study are not exactly the same as, but probably more complex than, the one investigated by means of practice, the results of the latter study nevertheless suggest the probability that the differences due to variations in practice are not wholly responsible for the correlations here found.

It therefore seems probable that the fact that, at least in a very simple performance, such as tapping the bell, a child's speed tends, in comparison with those of other children of the same age, to be about the same by whatever body member it is performed is partly or largely due to native differences in aptitude. Aptitude, in this case, would necessarily involve mechanisms other than the motor organ, e g , the hand, concerned. It might include neural, visual, perceptive, and muscular mechanisms engaged in the activity when performed by any particular organ

The Relation between Speed with one Member and Speed of Both Members Acting Alternately

A main generalization resulting from the results thus far secured is that in each type of simple motor performance a child tends to be typically fast, average, or slow, but that his relative speed in one type of performance does not indicate with any degree of reliability his relative speed in other types of activities In connection with this generalization, the correlations of a performance executed by neither of the opposite members alone but by each alternately may be most intelligibly considered. How these correlations fit into the scale from the highest to the lowest is shown in Table 17.

Examination of the scale of average correlations in Table 17

[6]See Gates and Taylor (3)

TABLE 17

1	Av *r* of performance in same activity (bell) with same member on same side	823
2	Av *r* of performances in same activity (bell) with same member on opposite side	777
3	Av *r* of performances in same activity (bell) with *different members* on the same side	683
4	Av *r* of performances in same activity (bell) with different members on opp sides	643
5	Av *r* of performances in same activity (bell) with same member one single and both alternately	.557
6	Av. *r* of performances in same activity (bell) with different members, *one single* and two alternately	.557
7	Av *r* of performances in same activity (bell) with different members, both alternately	463
8	Av *r different* activities, same member but different side	455
9	Av *r* different activities, different members but same side	415
10	Av *r* different activities, different members, different side	269

shows that correlations of speed in tapping the bell with the right and left member alternately, other factors being equal, fall about midway between the correlations of tests of the same activity and the correlations of tests of different activities. To say the same thing in a concrete form: If we know a person's speed in tapping the bell with his right hand we can predict better how rapidly he can tap the bell with his left foot than how rapidly he can tap the bell with the right and left hand alternately. The latter prediction, however, will be better than a prediction of how rapidly the person can do some quite different task, such as sorting cards, placing marbles in a slot, punching holes, or articulating familiar words. The implication of these facts is that tapping a bell with the hands alternately is not the same type of activity as tapping with any member alone, although it is not so different a type as sorting cards or articulating words, etc. It falls midway between the two. This suggestion of the correlations seems to accord with a common-sense appraisal of the various activities.

Summary of the Main Conclusions

1. Tests of motor speed and dexterity in such tasks as placing marbles in a slot, sorting cards, pegging sticks in a board, clapping a bell, vocalizing familiar syllables, etc., in the case of children 4.5 to 6 years of age yield a low average correlation (approximately .24) with the Stanford-Binet mental age. Such tests, in other words, are poor indicators of intelligence.

2. The correlation of such tests with intelligence is probably somewhat greater among the young children than among older children and adults. This appears to be due to the fact that performance in the more complex of the 17 tests among the younger subjects is influenced somewhat by the child's ability to perceive effective ways of adjusting himself to the task and to achieve better methods of procedure. Some of the tests, in other words, are influenced somewhat by intelligence and are, therefore, not tests of motor dexterity, pure and simple, as they probably are in the case of adults.

3. The tests judged by observers to give least play to intelligence yield correlations with mental age of approximately .19, a figure which suggests that tests of motor dexterity, pure and simple, are as nearly independent of intelligence among young children as among adults.

4 The intercorrelations of the 17 tests suggest that motor speed is highly specialized in about the same degree among young children as among adults Young children who are rapid in one type of performance are only slightly more likely than children average or slow in that performance to be rapid in performance of other types. An analysis of the data shows, however, that the correlations vary from *nearly zero to rather substantial positive coefficients as the result of the influence of three factors* (*a*) the nature or type of the performance, (*b*) the type of bodily organ or mechanism involved, and (*c*) the side of the body (right or left) on which the mechanism is located The lowest or minimum correlation is found between tests which are different in all three respects. Thus, between sorting cards with the right hand and articulating syllables, the correlation is nearly zero

5 It was found that correlations tend to be high when the type of performance is the same, even when executed with quite different organs. To illustrate, tapping with the right hand tends to show substantial correlations with other tapping tests done with the left hand or finger or either foot

6. It was found that correlations tend to be above the minimum when the same organ, e.g., the hand, is used even if one type of task is done with one and another with the other.

7. It was found that correlations tend to be slightly above the minimum when the same bodily side is involved. Thus, if the first test used a mechanism on the *right* side of the body, predictions of other performances with organs on the right side are slightly better than predictions of performances similar, except that they are done with organs on the left side of the body.

8. Necessarily, correlations become higher when two of the three factors, instead of only one, are the same.

Methods of Giving and Scoring Tests of Motor Speed and Dexterity

The tests used in this experiment were chosen after considerable research and observation First, a study was made of all tests for motor skill, both for children and adults. Also a collection of social games of skill was made Secondly, these tests and games were presented to a group of kindergarten and primary teachers for criticism. As a result, many were thrown out Later, the remaining tests were

classified under (*a*) test, (*b*) type and description, (*c*) apparatus, and (*d*) scoring, then presented to a group of research students for criticism The tests retained were both those favorably considered and those considered doubtful. The third step was the experimentation. Children ranging from 3-11 to 6-0, chronological age, were used as subjects Special attention was given to the (*a*) type of success, (*b*) interest, (*c*) fatigue, and (*d*) satisfactions. As a result, the following tests with the following directions and methods of scoring were derived

Putting Marbles into Box

This test was chosen because of its simplicity, familiarity, universal interest, and easy scoring.

Apparatus. Two boxes and 50 marbles were used for this experiment. A wooden box 6¾ x 5½ inches with a 3-inch-hole cut at the intersection of the diagonals was used as the depository for the marbles. A smaller box 5 x 4 inches, and ¼ inch lower than the larger box was used as the container of the marbles. The boxes were placed on a table convenient to the child's height in such a way as to allow him freedom of movement of the arms The smaller box was placed in line with the edge of the table.

Direction. "You see this box with the hole in it. I want to see how fast you can drop these marbles into this hole, moving only one at a time like this [demonstrate]. When I say, 'Ready, go,' begin with your hand on a marble and work as fast as you can until I say, 'Stop.' Be sure to move only one marble at a time." *"Position, ready, go Stop."* Time—30 seconds

Score. 1 Number of marbles moved by right hand.
2. Number of marbles moved by left hand (child was permitted to use either hand in beginning).
3 Number of marbles moved by both hands
4. Errors made by each

Dropping marbles and moving two marbles at a time were counted as errors

Repetition of Syllables

Many syllables and phrases were tried out for this test, but some seemed too short (hindering a correct counting), some too confusing, and some too monotonous. *Baa, baa, black sheep* was finally chosen, it was both interesting to the children and easy to count.

In this test alone, it was difficult to get the children to continue for 10 seconds, the younger ones especially The method of having the child start with the stop-watch and stop with it was used and was successful in every case.

Directions "Do you know about *Baa, baa, black sheep?* [If the child does know it, he is ready to tell, if he doesn't, his interest can be solicited easily by a recital of the rhyme.] Now, then, since you know about *Baa, baa, black sheep,* I want to find out how many times you can call his name like this [demonstrate] until I tell you to stop When I say *'Ready, go,'* say *Baa, baa, black sheep* as many times as you can until I say, *'Stop'" "Ready, go Stop."*

Score. Number of times *Baa, baa, black sheep* is repeated in 10 seconds.

Errors. Parts of phrase given only Syllables repeated out of order Syllables incorrectly given (as *back* for *black*).

Clapping Bell

This test was found to be one of the most desirable in the try-out. It continued to be popular among all the children, but it was found best to run in other tests among the three tests with the bell; the ringing of the bell continuously was fatiguing to a number of the children. The test was very easy to score

Apparatus. A board of soft pine wood was used with the bell placed equally distant from the sides and 4½ inches from the front. The 4½ inches gave sufficient room for the elbow to be off the board when clapping with the hands, and also enough room for the child to stand comfortably and see the bell in tapping it with his feet. The bell (ordinary classroom bell) was held in place by upholstering tacks Crosses were drawn to indicate the position of the hands and feet, the hands were placed on the cross, and the toes directly in front of the cross.

Directions "I want to find out how fast you can ring this bell. Place your hand here [at *X*] and clap the bell as fast as you can, like this [demonstrate], hit the bell and then the cross When I say, *'Ready, go,'* begin with your hand on the cross and go as fast as you can until I say *'Stop'" "Position, ready, go Stop."* Time—10 seconds

Score Number of times bell rings with (*a*) right hand, (*b*) left hand, (*c*) alternating hands.

Errors. Bell clapped more than once at a time. Board hit more than once at a time. Any other method of departing from directions.

Tapping Bell (Index Finger)

The same apparatus, the same directions (changing "hand" to "finger," and the same method of scoring was used as those for the preceding test

Tapping Bell (Feet)

The same apparatus, the same directions (changing "hand" to "foot"), and the same method of scoring was used as those for the Clapping Bell Test

Punching Holes

This test was suggested by Baldwin's Perforation Test, in which he used punching holes on paper held in frames It was decided in this case to use a thick tissue paper held between two boards, the upper board with holes all the way through, and the lower board with holes partly through. In this way, the control of the test was much better, as the pencil (blunt one) was always stopped at the same distance. Using a pencil the child took it in his hand as he is accustomed to hold it Only a very few (four or five) held it "fist-fashion."

Apparatus. Two boards 10½ x 13 inches were held together and clamped to a table of the correct height for the child. The upper board had holes bored through, while the lower had holes bored V-shape so as to catch the pencil. Thick tissue paper was placed between the two boards; this type of paper gave easily, and also "popped" as the pencil went through There were 11 rows of holes with 8 holes to the row, 1 inch apart and ½ inch in diameter

Directions "I want to see how fast you can punch holes in this board like this [demonstrate first line]. Begin here at this line [second] and work across the board like this [first line, second, etc], as fast as you can. When I say '*Ready, go,*' work as fast as you can until I say '*Stop*' " "*Ready, go* *Stop*" Time—30 seconds

General Observations

The following comments are made by Mrs. Scott who gave the tests.

1. As a rule, the children liked all the tests and were very much pleased to return the second day They objected seriously to direc-

tions the second day, and usually said, "I know, let me begin now." I made a point to repeat the necessary parts only (omitting descriptive). Their eagerness and readiness to begin may partially account for the increase in scores.

2. If any test was disliked at all it was the bell. This, however, was only by a few nervous and restless children.

3. I felt that these tests were not tests of the very best speed the children were capable of giving. On the other hand, they all chose (without exception) sooner or later a safer and surer method. If their method seemed to confuse them in the least, they slowed up. A number began very fast but, on showing haphazard and awkward movements, selected a pace that gave more accurate results. Some even asked, "Let me begin again." Other comments were, "I shouldn't have gone so fast," "I can do better than that," etc. The children, on the whole, were very self-critical.

TABLE 18

SCORES OBTAINED ON THE MOTOR SPEED AND DEXTERITY TESTS

Test	Average score	Average deviation	Amount second exceeds first test
Put marbles in box			
Right hand	18.36	1.89	.84
Left hand	17.12	1.70	.36
Both hands	23.02	2.50	1.20
Clapping bell			
Right hand	13.82	1.76	1.52
Left hand	12.91	1.71	1.18
Alternating hands	14.48	2.82	2.93
Tapping bell			
Right finger	9.88	1.98	1.24
Left finger	9.28	1.94	.54
Alternating fingers	12.50	2.56	3.32
Tapping bell			
Right foot	10.71	1.51	.50
Left foot	10.13	1.33	.94
Alternating feet	10.88	1.29	1.04
Sorting cards			
Right hand	11.43	2.36	—.36
Left hand	11.43	1.93	.74
Repeating syllables	7.96	.82	1.34
Punching holes			
Right hand	30.12	3.77	1.68
Left hand	27.96	3.86	.68

4 I felt that the third test, that of tapping the bell with the index finger, could be classed as a difficulty test. This was very hard to do for some of the children; it showed up the little use of the finer muscular movements Tapping the bell with the feet was also difficult for some, and most of the children did it very carefully for fear they would lose their equilibrium.

5. *The greatest amount of "awkwardness" and "clumsiness" showed up in the card-sorting. They seemed to know little about* separating cards and had many difficulties.

6. The children who made the best records on alternating hands and fingers on the bell test were those who "hit on" a method of moving both hands at the same time, or some modification of it. Those who used a "see-saw" movement altogether are *starred* on the test-scores.

Table 18 gives the average of the scores on the two trials of each test, the average deviation of the scores, and the amount which the second trial exceeded the first trial. The data are based on 50 children, average age 5.42 years and average Stanford-Binet mental age 6.56 years

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LES TRAITS CARACTÉRISTIQUES ET LES RELATIONS DE LA VITESSE ET DE LA DEXTÉRITÉ CHEZ LES JEUNES ENFANTS

(Résume)

On a fait subir à *cinquante enfants, âgés de 4½ à 6 ans, deux épreuves* dans chacun de 17 tests de vitesse motrice et de dextérité comme il suit (1) mise de billes dans une boîte, main droite, (2) même chose, main gauche, (3) même chose, les deux mains, (4) action de sonner une clochette, main droite, (5) même chose, main gauche, (6) même chose, une main et puis l'autre, (7) tapement d'une clochette, index droit; (8) même chose, index gauche, (9) même chose, index droit et puis index gauche, (10) même chose, pied droit, (11) même chose, pied gauche, (12) même chose, pied droit et puis pied gauche; (13) triage de cartes, main droite, (14) même chose, main gauche, (15) répétition de syllabes, (16) poinçonnage de trous, main droite, (17) même chose, main gauche Éliminant l'âge et l'inconstance des *tests par des méthodes statistiques, on a trouvé que les tests de dextérité* motrice semblent ne pas montrer de corrélations plus élevées avec l'intelligence au cas des jeunes enfants qu'au cas des adultes Il paraît aussi que la vitesse motrice est tant spécialisée chez les jeunes enfants, comme chez les adultes, que pour l'analyse professionnelle il vaut mieux mesurer des types individuels de vitesse et de dextérité que de les estimer des résultats collectifs L'analyse des corrélations parmi les tests montre que les corrélations tendent à être positives parmi les tests d'une fonction donnée, c'est-à-dire, le tapement, même s'il est exécuté avec des organes différents, c'est-à-dire, le doigt, le pied, le bras. On a trouvé que les tests tendent à être corrélés positivement quand ils sont exécutés du même côté du corps (droit ou gauche) ou avec le même organe (c'est-à-dire, *la main*) *quand même* les autres traits caractéristiques seraient différents L'influence de la similarité de *fonction* a été beaucoup plus grande, cependant, que celle de l'identité du *côté du corps* ou de *l'organe* employés

GATES ET SCOTT

EIGENSCHAFTEN UND BEZIEHUNGEN DER MOTORISCHEN SCHNELLIKEIT UND DER GESCHICKLICHKEIT BEI JUNGEN KINDERN

(Referat)

Es wurden an 50 Kindern im Alter von 4½ bis 6 Jahren je zwei Versuche gemacht mit 17 Tests zur Prufung der motorischen Schnelligkeit und der Geschicklichkeit, wie folgt (1) mit der rechten Hand Murmeln in eine Schachtel legen, (2) wie (1), nur mit der linken Hand, (3) das selbe, mit beiden Handen, (4) mit der rechten Hand eine Glocke lauten; (5) das selbe, mit der linken Hand, (6) das selbe mit beiden Handen abwechselnd, (7) mit den rechten Zeigefinger eine Glocke antappen, (8) das selbe, mit der linken Hand, (9) das selbe, mit abwechselnden Handen, (10) das selbe, mit dem rechten Fuss, (11) das selbe, mit dem linken Fuss, (12) das selbe, mit abwechselnden Fussen; (13) mit der rechten Hand Karten aussondern, (14) das selbe, mit der linken Hand; (15) Silben wiederholen, (16) mit der rechten Hand Locher stechen, und (17) das selbe, mit der linken Hand. Nachdem die Faktoren des Alters und der Unzuverlassigkeit statistisch ausgeschieden worden waren, zeigte es sich, das die motorische Geschicklichkeit bei jungen Kindern nicht enger mit Intelligenz verbunden zu sein scheint, als bei Erwachsenen Es zeigte sich ferner, dass die motorische Geschicklichkeit bei jungen Kindern, wie auch bei Erwachsenen, so eng spezialisiert ist, dass es bei Analisierung der Berufsanlage besser ist, besondere Formen der Schnelligkeit und der Geschicklichkeit zu messen, als sie nach Gesamtzahlen abzuschatzen Die Analyse der Korrelationen zwischen den Tests zeigt, dass die Korrelationen zwischen Tests einer besonderen Tatigkeit (function), zum Beispiel das Tappen (tapping), eine positive Richtung haben (tend to be positive), selbst wenn sie mit verschiedenen Organen,—z B., Finger, Fuss, Arm,—ausgefuhrt werden. Man fand, dass die Tests in die Richtung neigen, positive Korrelationen mit einander zu liefern wenn sie auf der selben Seite des Korpers (rechts oder links) oder mit dem selben Organ ausgefuhrt werden, auch wenn sie in Bezug auf andere Eigenschaften verschieden sind. Die Wirkung der Ahnlichkeit der Tatigkeit war aber viel starker als die der Identitat der Korperseite oder des in Anspruch genommenen Organs

GATES UND SCOTT

A PRELIMINARY STUDY OF THE EFFECT OF DELAYED PUNISHMENT ON LEARNING IN THE WHITE RAT*

From the Animal Laboratory of the Department of Psychology, Columbia University

C. J. WARDEN AND S DIAMOND[1]

While numerous investigations have been made in recent years concerning the effect of delayed positive incentives on learning, the matter of delay in the case of negative incentives, or punishments of one sort or another, has been almost wholly neglected Aside from the significance of the problem as related to the systematic treatment of the general topic of motivation, the influence of short delays in administering punishment for errors bears directly upon certain types of laboratory technique in which the reward-punishment combination of motivation is employed. This is especially true in the case of the discrimination method, where, as a rule, the temporal relations between the response and the two diverse incentives are often different. In the Yerkes-Watson apparatus, for example, the electric grills are placed directly beneath the stimulus plates, while the food is located some distance away This means that punishment follows an incorrect response immediately, whereas a short interval of time must intervene between a correct response and the reward. The interval may be so short as to be inconsequential in the case of the white rat and other animals that go directly to the food, but in other forms, such as the ring dove, for example, the interval may be a matter of some seconds Unless it be known that immediacy of punishment is not important it is clearly impossible to compare the incentive value of reward and punishment under these conditions, as has sometimes been done. As our results show, the temporal factor must be taken into account before direct comparisons of positive and negative incentive, as related to this and other types of habit forma-

*Received in the Editorial Office, September 30, 1930

[1]This experiment was planned and carried out in cooperation, the junior author securing and tabulating the data and the senior author being responsible for the report in its present form.

tion can justifiably be made. The aim of the present study, which was carried out during 1927-1928, was to make a preliminary determination of the influence of short intervals of delay in administering punishment upon the rate of learning a simple maze. The results should be considered as more or less tentative, since the groups tested were small and the number of intervals employed falls within a narrow range.

A simple Y-maze, as shown in the diagram of Figure 1, was used

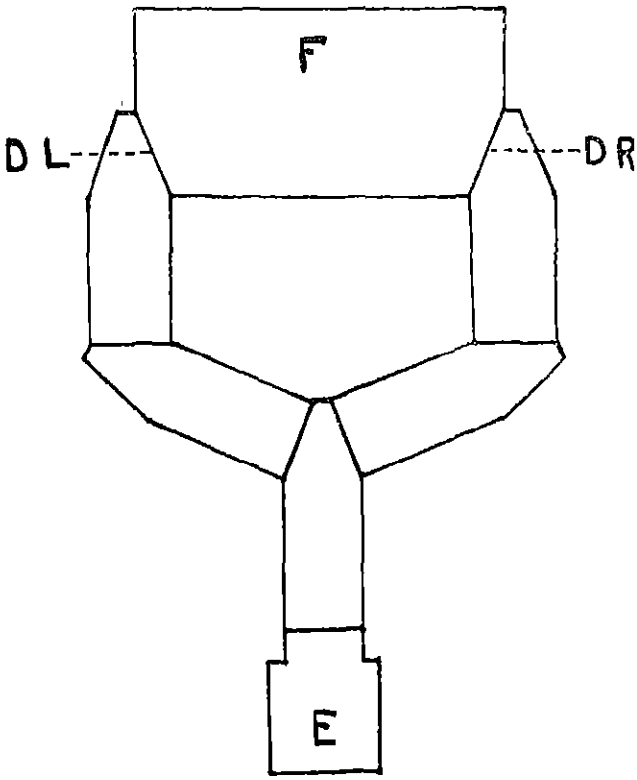

FIGURE 1

DIAGRAM OF THE APPARATUS

The entrance box and pathways were arranged from units of the Warner-Warden maze. The end box, *F*, was constructed of wood with mesh top, and was approximately 10 x 20 inches in size. *DL* and *DR* were doors which could be closed by manual operation of a string and pulley device.

in making the tests. The maze was arranged from an entrance compartment and 5 pathway units of the Warner-Warden maze placed upon a varnished table top. The food box was 10 x 20 inches in size, with wooden sides, a wire-mesh top, and a floor consisting of two large electric grills placed in the right and left positions, the two together covering the entire floor area of the food box Each grill was made of a slab of bakelite 0.5 inches thick, wound with No. 18 copper wire at intervals of 0 25 inches in such a way that the wires from each terminal alternated, thus insuring a shock when any two adjacent wires were touched. The grills were supplied with current by *means of the electrical system developed in connection with the* Columbia obstruction apparatus Four degrees of shock were used in various phases of the experiment, the character of the physical stimulus being indicated by the following readings. Shock A, 700 volts, 0 921 m a., Shock B, 1000 volts, 0 132 m a., Shock C, 700 volts, 0 180 m.a , Shock D, 500 volts, 0.192 m a The two doors, *DL* and *DR*, located at the left and right entrances to the food box, were operated manually by a simple string and pulley device so placed as to fall outside the visual field of the animal. The distance from the point where the pathways diverge to either of these two doors was 20 inches

The results presented cover the training of 13 white male rats, two having been eliminated finally because they formed position habits which could not be readily broken and which rendered them valueless for the present purpose. The animals were about 75 days of age when the experiment was begun and weighed, on the average, 73 grams The regular diet consisted of milk-soaked, whole-wheat bread, with a special ration of lettuce weekly. They were fed daily for 30 minutes, in groups, after the completion of the daily tests. The positive incentive consisted of a small piece of dry whole-wheat bread placed in the food box close against the center of the back wall Dry bread was used so as not to short-circuit the grill The animals were given opportunity to become adapted to the experimental situation in connection with the following preliminary conditions. (*a*) one trial of two minutes, with both doors open and with the incentive in the food box, given on four successive days, (*b*) one trial of two minutes, given on the three following days, the doors being closed behind the animal as soon as the food box had been entered By the end of this week of preliminary work, the animals

had formed the habit of going directly to the food without wasting time in exploratory activity and had ceased to be disturbed in any way by the manipulation of the doors.

The training period proper may be divided into the two following cycles which followed one another in close succession in the case of each animal: (*a*) training each of the 14 animals to turn to the right until the norm of 10 successive correct responses was reached, and (*b*) training the animals to turn to the left under different conditions of delayed punishment. The purpose of the first phase of the training was to establish a definite mode of response in all the animals so that the effects of delay in the second phase would be more clearly represented in the learning score This technique would seem to be preferable to that usually employed in which chance reactions to right and left are assumed to hold previous to training, when, as a matter of fact, direction preferences are more than likely to be present in the case of the white rat It was hoped that this procedure would reduce individual differences in rate of learning within the groups representing the various delay intervals in the second phase, since all the animals would start with the same general direction habit at presumably the same degree of fixation

During the first cycle, in which all the animals were trained to turn to the right, two trials in immediate succession were given daily, except that the first six trials of the cycle were given at the rate of one per day. The lowest degree of shock (Shock A) was employed, the current being turned on for 10 seconds immediately after the animal had entered the food box through the left pathway When the animal entered through the right pathway, it was allowed a nibble of the dry bread used as the positive incentive The norm of mastery was set relatively high in order to equalize the degree of fixation of the habit of turning to the right in the animals. The norm of 10 successive correct trials required perfect runs on 5 days in succession.

The results of the training for the first cycle are shown in Table 1 These data seem to demonstrate the prevalence of right and left preferences among white rats even on their first contact with an experimental apparatus. As will be seen, most of the animals showed a rather marked left preference, turning to the left much more often than to the right, even when regularly being given a shock for so doing No explanation for this dominant tendency can be offered

TABLE 1

TRAINING TO THE RIGHT WITH IMMEDIATE PUNISHMENT (SHOCK A)

Responses	Animal Number												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Right turns	20	13	9	7	12	3	6	1	5	11	6	4	3
Left turns	18	23	27	18	33	8	34	6	16	17	6	6	6
Total	38	36	36	25	45	11	40	7	21	28	12	10	9

It may have arisen during the 7 preliminary trials, but since the data were not preserved, no evidence can be offered either way. It does not appear to be related to any definite pre-training condition, so far as we have observed. The array of totals indicates the trial at which the several animals reached the norm of mastery required, the 10 right turns comprising the norm not being included in the scores The range of individual differences is extremely wide for so simple a problem, as may be seen from inspection of the totals.

As soon as a given animal had reached the set norm of mastery, it was placed in one of the delay groups and began at once the training of the second cycle in which a left turn was required. The interval of delay was measured by means of a stop-watch reading to fifths of a second The allocation of animals to the several delay groups was made without reference to the performance scores of the first cycle The following five groups were arranged: (*a*) zero delay, rats 1, 2, 3, 4; (*b*) 4 seconds' delay, rats 5, 6, 7; (*c*) 8 seconds' delay, rats 8, 9, (*d*) 12 seconds' delay, rats 10, 11; and (*e*) 20 seconds' delay, rats 12, 13. No change was made in the general conditions of training in passing from the first to the second cycle, except in the matter of the strength of shock employed. It seemed advisable to use a higher degree of shock in training to the left in order to counteract any possible adaptation of the animals to Shock A, as applied in the first cycle Shock B, the next higher step, was therefore employed at the beginning of the second cycle It was soon evident, however, that the animals readily became adapted to an electrical stimulation of this strength, and hence Shock C was substituted Even this degree of shock did not seem adequate, and, after 6 trials, or three days of training, it was replaced by Shock D, which was then continued throughout the remainder of the experiment. Since the training of the several animals had reached different stages when the discovery was made that Shock B was too weak, the

TABLE 2
TRAINING TO THE LEFT WITH DELAYED PUNISHMENT, USING SHOCKS B, C, AND D

Rat	Shock B Total	Shock B Left	Shock C Total	Shock C Left	Shock D Total	Shock D Left	Gr Total Total	Gr Total Left
1	12	1	6	1	4	0	22	2
2	12	1	6	0	2	0	20	1
3	12	0	6	0	17	9	35	9
4	40	1	6	0	28	0	74	1
5	12	0	6	0	63	13	81	13
6	40	10	6	1	79	9	125	20
7	12	0	6	0	25	12	43	12
8	40	0	6	0	24	7	70	7
9	40	1	6	0	27	2	73	3
10	40	5	6	0	27	1	73	6
11	40	0	6	0	48	11	94	11
12	40	0	6	0	48	4	94	4
13	40	0	6	0	76	10	122	10

number of trials with punishment at this strength varies, being only 12 in some cases and 40 in the others, as indicated in the first column of Table 2.

The number of trials given at each strength of shock, together with the number of left turns, or correct responses in each case, will be found in Table 2. The 10 correct trials comprising the norm of mastery in connection with Shock D are not included in the score recorded in the table. On account of the fact that the number of trials in the early part of the training period, when Shock B was employed, differs from animal to animal, it is difficult to know just how to compute the final score for the several delay groups. It seems hardly fair to lump all the trials together, regardless of the degree of shock employed, since it is evident from the data presented in the second column of Table 2 that Shock B was not very effective. The same can also be said in the case of Shock C, but, since the number of trials at this strength was constant throughout, no special problem

TABLE 3
TRIAL AND ERROR SCORES IN LEARNING LEFT TURN WITH DELAYED PUNISHMENT

Scorings	0 delay Tr	0 delay E.	4 sec Tr	4 sec E	8 sec Tr.	8 sec E	12 sec Tr	12 sec E.	20 sec Tr	20 sec E
Shock D score	12.8	10.5	55.7	44.3	25.5	21.0	42.5	36.5	62.0	55.0
Total Score	37.8	34.5	81.0	68.0	71.5	66.5	83.5	75.0	108.0	101.0

arises here. Nor does it seem quite fair to assume that the 28 extra trials given some of the animals with Shock B should be entirely ignored, even though they appear to be relatively ineffective. The results for the several delay groups, therefore, have been computed in both ways as given in Table 3. In the first array, the group scores are computed on the basis of performance after Shock D was introduced, while the values of the second array represent the total number of trials involved, regardless of the degree of shock employed.

It will be clear from an inspection of Table 3 that the general trend of the results is the same, regardless of which method of computation is used. The outstanding fact is that a delay as short as 4 seconds lowers the value of the punishment to a most remarkable extent. The score for a single rat at a 2-second delay, which was not included in the tables, was approximately twice as high as the above score for zero interval. On the whole, therefore, there appears to be a general tendency for the value of punishment of this sort to decrease as the interval of delay increases. Doubtless, this tendency would be more clearly marked if larger groups had been used. The results indicate that the temporal factor is important in the case of negative as well as of positive incentives, even in a learning situation of this simple type. Moreover, it is evident that determinations of the relative value of reward and punishment cannot be made unless the temporal factor is equalized in administering both types of incentives under a given set of conditions.

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UNE ÉTUDE PRÉLIMINAIRE DE L'EFFET DE LA PUNITION RETARDÉE SUR L'APPRENTISSAGE CHEZ LE RAT BLANC

(Résumé)

C'est un premier essai de déterminer l'influence du retardement de la punition pour les erreurs dans les expériences avec les animaux, suivant la manière des stimulants positifs retardés. On a employé un simple labyrinthe Y, tous les animaux étant entraînés à tourner à droite, comme préliminaire,, pour qu'ils puissent tous commencer le vrai entraînement avec le même habitude de direction. Ensuite, on a divisé les animaux en groupes et on les a entraînés à tourner à gauche dans une des conditions suivantes de retardment dans les chocs pour les erreurs: nul retardment, 4 seconds, 8 secondes, 12 secondes, 20 secondes. Un retardement de plus de 4 secondes a augmenté plus de deux fois le nombre des épreuves à apprendre, avec la tendance de la perte d'habileté à varier avec la longueur de l'intervalle du retardement. On suggère qu'il faut tenir compte du facteur temps en faisant des comparaisons directes de la valeur relative de la récompense et de la punition dans les expériences avec les animaux.

WARDEN ET DIAMOND

EINE VORBEREITENDE UNTERSUCHUNG ÜBER DEN EINFLUSS DER AUFGESCHOBENEN BESTRAFUNG AUF DAS LERNEN DER WEISSEN RATTE

(Referat)

Wir haben hier den ersten Versuch, den Einfluss der Aufschiebung der Bestrafung von Fehlern bei Arbeit mit Tieren auf die selbe Weise wie bie positiven Antrieben zu bestimmen. Ein einfaches Y-Labyrinth wurde gebraucht und alle Tiere wurden vorlaufig dressiert, sich rechts zu wenden, so dass alle die eigentliche Dressierung mit der selben Richtungsgewohnheit anfangen konnten. Die Tiere wurden dann in zwei Gruppen verteilt, und dressiert, sich links zu wenden, unter einer der folgenden Verschiebungsbedingungen, bei Bestrafung der Fehler durch elektrischem Reiz: 0 Verschiebung, 4 Sekunden Verschiebung, 8 Sekunden, 12 Sekunden, 20 Sekunden. Eine Verschiebung von 4 Sekunden erforderte zum Lernen mehr als die zweifache ursprungliche Versuchszahl, und es zeigte sich bei dem Verlust an Leistungsfahigkeit eine Tendenz, mit der Lange des Verschiebungsintervals zu wechseln. Es wird vorgelegt, dass bei direkten Vergleichungen des relativen Wertes der Belohnung und der Bestrafung bei Arbeit mit Tieren der Zeitfaktor in Betracht gezogen werden muss.

WARDEN UND DIAMOND

VISUAL APPREHENSION IN THE MAZE BEHAVIOR OF NORMAL AND FEEBLEMINDED CHILDREN*†

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SANTE DE SANCTIS

The maze method, so widely employed in America in the researches of comparative psychology, may be used not only in the study of the learning process and habit formation in animals, but also in the study of many other problems, including those of human psychology, as well as those of comparative psychology.

In the Institute of Psychology of the University of Rome the maze method has been used for a number of studies of human psychology. The *pencil maze* has been used in these studies. This type of maze makes possible the testing of the visual-kinaesthetic imagery of the subjects and their capacity of orientation.

Vera Roncagli (1) carried out experiments on normal adults and infants, using three types of maze pattern, that of the Chicago Laboratory, that of Pizzoli, and one designed at the Rome laboratory expressly to test the capacity of orientation in a situation which offers several possibilities (Figure 1)

In one of her experiments with the Chicago maze, Roncagli used as subject an abnormal child, characterized as weak and unstable, with mental incapacity of slight degree (This experiment ran from January 25 to February 21, and from May 1 to May 4, 1916.) This subject was found to be less *reflective* than the normal subject of equal age, also he failed to show those signs of conscious activity which make human learning an intellectual, and not a purely mnemonic, process. The spontaneous recollection of a series of tests performed at 24-hour intervals was slow to manifest itself in the abnormal subject, and was not at all frequent. Automatism predominated in his acts There appeared to be no conscious utilization of experience in the elimination of errors Learning appeared to be of a semi-automatic character, it proceeded principally with the aid of motor images, but practice was generally maintained. In these respects the learning process of the feebleminded seemed to resemble

*Received in the Editorial Office, September 26, 1930

†Translated from the Italian by Leland L Atwood and Luberta Harden

that of animals, the "casual" learning of Thorndike. Moreover, as compared with the normal subject, the feebleminded person does not orient himself in the maze as rapidly as does the normal person; he learns more slowly because he is less attentive and has a less exact memory, and because he does not persist as well in practice. The findings of Roncagli's study could not be considered conclusive Since she dealt with but one subject and since that subject appears to be a *borderline* case of feeblemindedness (displayed mental incapacity of *slight degree*), the objection might be raised that the differences observed between that child and a normal child of equal age might be merely a matter of individual differences and might not pertain to the feebleminded as a group, as compared with the normal

In order to throw further light on the capacity of orientation of the feebleminded in the maze, the present writer carried out an experiment with 12 boys with a *medium grade* of incapacity (pupils of an *Asili scuola di Roma*) for four consecutive days, repeating the experiment at 24-hour intervals, and with 20 boys and girls of normal development (pupils of an *Asilo d'infanzia* and of a *Scuola comunale* of Parrano in Umbria). The purpose was to test the orientation of the subject when he had been given the task of finding an escape from an imaginary danger or the way to an imaginary reward.

The De Sanctis maze (Figure 1) was used. The instructions were as follows.

"Look at this figure. Suppose that you find yourself here in the center, and that you must get out of the maze in great haste because you are in danger (or because you are hungry and the food is out-

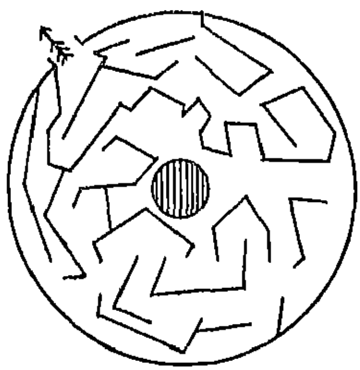

FIGURE 1

side the gate of the maze, or because, just as soon as you are out of the gate, you will receive a chocolate). Here is a pencil; follow quickly the shortest path which you must take to get out of this gate at the left. Go!"

A record was taken of the time, the behavior of the child at the beginning and during the experiment, the trials, and the errors. Whether the subject was successful in finding the exit, or not, the experiment was repeated after a few hours or days if the shortest path was not traced in a given time.

An analysis of the data shows some interesting results, and of these I present those which interest me most with respect to the psychopathology of the feebleminded I assume that all the normal or abnormal subjects easily imagined the three incentives to escape from the maze as quickly as possible

Normal Subjects

The total number of normal subjects used in this experiment was 20; of these, 9 were of preschool age (from 3 to 6 years) and 11 were of school age (from 7 to 12 years). The former will be referred to as the *preschool group*, and the latter as the *school group*.

No subject of the preschool group presented a *general*, i.e., a visual-kinaesthetic, *orientation*; five proceeded by trial and error, i.e., a *motor orientation*, of these five, one solved the task after one repetition of the experiment. On the other hand, 9 of the 11 school children displayed *general orientation*, and only one proceeded by trial and error, while the remaining subject appeared to proceed by general orientation and by trial and error alternately, i.e., he displayed a *mixed orientation*

Observations upon the speed of reaction revealed that the younger subjects all proceeded slowly, with but one exception, while seven of the older group proceeded rapidly, and but four moved slowly

The ability to attend and to maintain attention was found to be distributed as follows of the nine preschool children, four showed such ability, while five seemed to be lacking in this respect, one through sensory defect, one through indifference, one through a "scattering" of attention, one through timidity, and one through emotionality The 11 older subjects appeared to show the ability.

All of these normal subjects learned the maze with practice, although one eight-year-old girl was very slow in understanding and

in performance during five minutes she looked at the maze when it was first presented without the slightest understanding of what to do

Feebleminded Subjects

Twelve feebleminded subjects were used, all of school age (from 7 to 13 years) Ten showed a deficiency of *medium* grade [probably of the imbecile level], one a deficiency of *high* degree [probably of the idiot level], and one a deficiency of *slight* degree [probably of the moron level], as determined by the De Sanctis mental tests.

Of these 12 feebleminded subjects, six showed orientation (*visual-kinaesthetic apprehension*), two proceeded by trial and error (*motor orientation*), and four showed *mixed orientation* Eleven succeeded in solving the problem, only the subject with *high* degree of deficiency failing. Eight proceeded rapidly at the task, and three worked slowly. All of the 11 subjects were capable of learning with practice Seven displayed the ability to attend and to maintain attention, while a lack of such ability was noted in four of the group

Conclusions

The general visual-kinaesthetic orientation, which I shall call "visual apprehension" (*colpo d'occhio*), i.e., looking at the maze without running the pencil through the various paths, does not occur with normal children of preschool age of either sex, even though they be pupils in the kindergarten. These young children either do not understand the task (they do not find their way about in the drawing of the maze), or they are indifferent, or emotionally upset, or distracted. If they do succeed in solving the problem, that is, in finding the exit, they do so by using the method of trial and error, running through the various paths until they come up against the blind-alley stops. This procedure necessarily involves a great number of repetitions of the experiment and a consequent loss of time On the other hand, all of the normal older children solve the problem (come out by the shortest path), as do adults, by employing visual apprehension. In fact, their solution is practically as rapid as is that of adults, the matter of speed of solution being subject to great individual differences.

The feebleminded children of the same chronological age behave for the most part like the older normal children and adults They use visual apprehension in escaping from the maze, only a minority resorting to the method of trial and error. They are, in general,

slower than the normal subjects, probably because of their inability of concentrated attention

Visual apprehension (*"colpo d'occhio"*) is an inherent, rather than a learned, ability It is an intuition of the whole, and appears to be facilitated by a condition arising from the level of instinct, i e, escape from danger The failure of certain children to solve the maze problem is probably due to causes other than the lack of visual apprehension In such cases, learning proceeds by trial and error. Even in this type of learning, an image is formed of the shortest path to the exit. Thus we find that the acquisition of spatial knowledge by visual apprehension is an ability not only of adults and children of normal development but also of the feebleminded.

The fact that children displaying a marked degree of feeblemindedness (although not true idiots) do not differ in a marked degree from normal subjects of the same chronological age leads me to think that inability to learn spatial data by means of visual apprehension does not form part of mental deficiency, rather that in cases of deficiency visual apprehension is sometimes hampered by poor attentive capacity.

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L'APPRÉHENSION VISUELLE DANS LE COMPORTEMENT DES ENFANTS NORMAUX ET DES ENFANTS ARRIÉRÉS DANS LE LABYRINTHE

(Résumé)

L'auteur a fait une expéprience avec 20 garçon normaux (9 entre les âges de trois et de six ans et 11 entre sept et douze ans) et 12 arriérés (âgés de sept à treize ans) dans le but de determiner à quel degré l'appréhension visuelle a été employée dans l'orientation du sujet dans le labyrinthe DeSanctis On a dit au sujet d'imaginer qu'il échappait au danger ou qu'il devait recevoir une recompense quand il échapperait On a note trois types de l'orientation (*a*) générale (visuelle-kinesthésique), (*b*) motrice (essai et erreur), et (*c*) mixte (générale et motrice alternant) La première méthode, c'est-à-dire, celle comprenant l'appréhension visuelle a éte employee par les enfants normaux les plus âgés (non par les enfants de l'âge préscolaire) et par les arriérés du même âge chronologique, bien que ceux-ci aient été pus lents dans leurs réactions. On suggère que, puisque cette forme du comportement se montre chez les arriérés ainsi que chez les normaux, c'est une capacité inhérente plutôt qu'une capacité apprise.

De Sanctis

DIE VISUELLE AUFFASSUNG BEI DEM ERLERNEN EINES LABYRINTHES DURCH NORMALE UND GEISTESSCHWACHE KINDER

(Referat)

Der Verfasser hat eine Experiment durchgeführt an 20 normalen Knaben, (9 im Alter von 3 bis 6 Jahren, und 11 im Alter von 7 bis 12 Jahren) und an 12 *geistesschwachen Knaben (7 bis 13 Jahre alt)* *Die Absicht dieses* Versuches war, zu ermitteln bis zu welchem Grade die Versuchsperson bei der Orientierung in dem Labyrinth von De Sanctis von visueller Auffassung (visual apprehension) Gebrauch machten Man sagte der Vp sie solle sich einbilden, dass sie sich von einer Gefahr flüchte, oder dass sie nach gelungenem Entkommen eine Belohnung erhalten würde. Es wurden drei Formen der Orientierung bemerkt (*a*) eine allgemeine (visuel-kinesthetisch) (*b*) eine motorische (die Orientierung mittels Versuch und Irrtum) (trial and error), und (*c*) eine gemischte Form (zwischen der allegemeinen und der motorischen alternierend). Die erste Methode—die in der die visuelle Auffassung mit einbegriffen war—wurde von den älteren normalen Kindern (nicht von vorschulpflichtigen Kindern) und von den geistesschwachen Kindern in dem selben chronologischen Alter gebraucht, obwohl die letzteren in ihren Reaktionen langsamer waren Man weist darauf hin, dass diese Form des Verhaltens (behavior), da sie sich sowohl bei Geistesschwachen wie bei Normalen zeigt, wohl eher eine angeborene (inherent) wie eine erlernte Fähigkeit darstellt

De Sanctis

THE FACTOR OF GENERAL ORIENTATION IN MAZE LEARNING IN THE WHITE RAT*

From the Animal Laboratory of the Department of Psychology, Columbia University

C. J. WARDEN AND F. R FOX[1]

In much of the early literature on maze learning in the white rat it would seem that the major emphasis was placed upon the fixation of the several elements of the pattern, while the more general factors involved were passed over rather lightly. Attention was first directed specifically to the factor of general orientation by Peterson (5, 6) in connection with his "completeness of response" principle Further work bearing upon the importance of general orientation in maze learning has been reported by Hubbert and Lashley (4), Dashiell (2, 3), and Warden (7). In the main, the evidence presented in these later studies is drawn from an analysis of error data in which it is found that the relative difficulty of various units of the pattern is related more or less directly to the appearance of the tendency to orient toward the food box. This is true not merely of backward errors, but, as each of these studies shows, of certain types of forward culs-de-sac errors as well. The present report, covering an investigation conducted in 1927-1928, offers further evidence on this point in connection with the several experimental conditions to be described.

TEST 1

The first test deals with the influence of various types of rotation after the maze habit has been established upon the locus of the errors made during later maze performance The apparatus used was a 5 culs-de-sac pattern, as shown in the diagram of Figure 1, arranged from units of the Warner-Warden maze (8). White rats, approximately 75 days of age, and weighing 72 grams, on the average, were employed. The apparatus was set up in the room in which the rat

*Received in the Editorial Office, September 30, 1930

[1]This experiment was planned and carried out in cooperation, the junior author securing and tabulating the data, and the senior author being responsible for the report in its present form

colony was housed. The fact that the cages were all on one side of the maze suggested the possibility that noise from the colony might serve as a secondary cue. This does not seem likely, however, since no disturbance resulted when the colony cages were moved 90° to the right and placed the same distance from the maze. A radiator stood several feet away on one side of the maze, and a check on possible cues from this source was had by turning the radiator off and placing electric stoves on the opposite side of the apparatus. Since this had no apparent influence on the performance of the animals, it is likely that the radiator, which was kept at a much lower temperature than the stoves, was also ineffective.

Each animal was given one preliminary trial per day for 10 days,

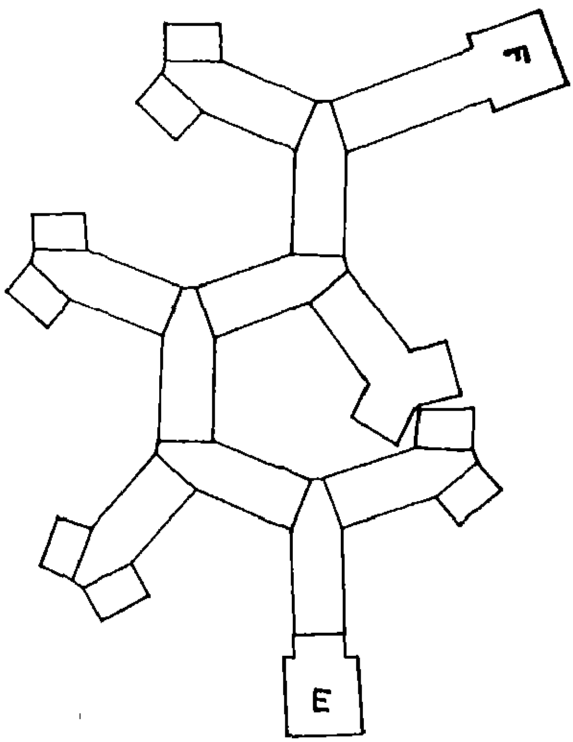

FIGURE 1

Five Culs-de-sac Pattern of Warner-Warden Maze

during which it was allowed to explore the outside of the maze and, after locating the food box, to feed for 10 seconds If the animal failed to locate the food box within 2 minutes it was carried there by the experimenter. This procedure doubtless considerably reduced the random exploration of the early trials, since in no case during the regular training series did an animal take longer than 90 seconds to reach the food box It probably had the effect also of preventing backward errors in the later training. After feeding for 10 seconds, the animal was placed in the feeding cage with access to whole-wheat bread soaked in milk for 30 minutes.

One trial per day was given in the training series proper, the animal being allowed a nibble of moistened McCollum's diet after reaching the food box, and then being transferred to the feeding cage as in the preliminary trials An error was checked whenever the rat extended its nose into a cul-de-sac, only culs-de-sac errors being scored Except in the case of Groups C and D, in which over-learning was specifically intended, the norm of mastery required in the initial learning was always 4 successive errorless trials (Norm A) In these two groups the norm set was 27 errorless trials out of 30 (Norm B) In the relearning series following rotation, Norm A was employed throughout, except in the case of Groups E and F in which no norm whatever was used, data being taken only on the

TABLE 1

A SUMMARY OF GROUPS AND CONDITIONS

Group	Size of Group	Initial Learning Conditions	Relearning Conditions
A	9	Norm A	Maze rotated 90° to the right; relearning to norm A.
B	4	Norm A	Cage and maze rotated 90° to the right about common axis, relearning to Norm A
C	4	Norm B	Same as in B except animals caged in new position 48 hours before relearning began
D	4	Norm B	Maze rotated 90° to right after overlearning, relearning to Norm A
E	3	Norm A	Dizziness induced by 70 revolutions in 20 sec in drum, maze not rotated, disturbance on 4 trials noted
F	3	Norm A	Same as in E, except maze rotated 90° to right in addition to dizziness, disturbance on 4 trials noted

TABLE 2

SHOWING INFLUENCE OF ROTATION AND OTHER FACTORS ON MAZE PERFORMANCE, INTRODUCED AFTER LEARNING HAS BEEN COMPLETED

Group	Trials Av	Trials M.V.	Time in Secs Av	Time in Secs M.V.	Time in Secs Final	Errors Av.	Errors M.V.	Percentage error scores for culs-de-sac 1	2	3	4	5
A	5.2	1.4	67.4	19.6	3.2	10.6	3.7	4.4	2.3	1.8	1.0	0.5
	5.2	3.2	52.0	20.8	3.2	9.6	3.3	5.2	1.2	0.9	2.1	0.6
B	3.0	0.0	86.3	22.0	4.0	8.5	3.0	4.1	1.9	2.0	2.0	0.0
	4.5	1.0	47.8	17.6	3.6	10.0	2.5	5.3	1.4	1.0	2.0	0.3
C	5.5	2.3	68.8	7.2	2.6	9.5	2.0	4.9	1.5	2.6	0.7	0.3
	3.0	1.5	36.5	20.5	3.0	5.3	2.8	5.9	1.7	1.6	0.5	0.3
D	3.5	0.8	60.5	5.9	2.7	8.5	0.8	4.0	2.4	1.6	1.2	0.3
	3.5	0.8	66.6	13.6	2.8	10.0	2.0	4.1	2.5	2.2	0.9	0.3
E	9.0	2.7	105.1	26.3	4.8	12.2	2.0	6.6	1.9	1.1	0.0	0.4
	4 only		69.3	18.2		6.3	0.8	..	.	.	.	.
F	4.3	0.4	74.7	34.2	4.0	7.0	2.7	7.0	1.2	0.7	1.1	0.0
	4 only		67.4	16.8		6.3	2.0			.		.

first 4 trials following rotation. Time per trial was taken with a stop-watch throughout.

The several conditions investigated are indicated in Table 1 The initial learning and the relearning after rotation was continuous for each animal, except that an extra day was allowed to intervene in the case of Group C in order to allow a 48-hour period of adaptation to the rotated cage and maze before beginning to relearn the latter in its new position. As will be seen, all of the groups except the first are relatively small, and this fact must be taken into account in drawing conclusions regarding the influence of the various conditions introduced.

The results secured in this experiment are presented in Table 2. In addition to the total time score for each group, as shown in the third column, the "final" score covering the time record of the four perfect runs of the norm of mastery is given in the fifth column The scores showing the distribution of errors in the several culs-de-sac are given in percentages in order to make them more strictly comparable from group to group. The record of Group A, in which the usual method of maze rotation was applied, may be taken as basic to a comparison of the results obtained when other conditions were introduced

It is interesting to note that the influence of rotation was not

significantly reduced when both cage and maze were rotated together about their common axis, as in the case of Group B In both the initial learning and the relearning tests, the animals were carried from the cage to the entrance box in a straight line and placed in the food box with forward orientation. The animals had been transferred to the new cage position 24 hours before the first trial was given, or immediately after the last trial of the initial training series. It was thought that an extra day in the new position might reduce any possible emotional disturbance, but this change in procedure, in the case of Group C, did not affect the rotation scores markedly, and no conclusion seems to be warranted on account of the small size of the group. The results for Groups C and D, in which Norm B was used in the initial learning, seem to indicate that rotation effects are not influenced to any great extent by the overlearning represented

In the case of Group E, dizziness was substituted for rotation The dizziness was induced by rotating the animals singly in a revolving-drum activity cage turned on the side so that the axis was vertical. Approximately 70 revolutions of the wheel in 20 seconds was sufficient to make the animals so dizzy that, when placed in the entrance box, they became rigid with limbs outstretched. After a time they would suddenly jump up with a frog-like jerk and approach the door of the maze, often moving in a small circle. The direction of revolving the wheel was determined by chance. The amount of disturbance on running the maze under these conditions appears to be about the same as that which occurred in general from rotation effects, insofar as can be judged from the record of the first four trials. When both dizziness and maze rotation was introduced, as was true in the case of Group F, the resulting disturbance did not seem to be greater than when the animals were made dizzy and the maze not rotated, as with Group E

The findings enumerated above are in general agreement with the results obtained by others in rotation work on the white rat. Our primary interest, however, was not so much in the effect of rotation itself as in the possible transfer of tendencies established during the initial training to the rotation situation It seems highly probable that a general orientation tendency set up during the initial training would itself become a disturbing factor after rotation, since the absolute direction of the food box would be changed The results seem to support this presumption. In Group A, for example, the percent-

age of errors in the several culs-de-sac shows a fairly regular decrease from the first one to the fifth, in the learning series. In the relearning series, however, the order is 1, 4, 2, 3, 5, which means that culs-de-sac 2 and 3 were entered less often and culs-de-sac 1 and 4 significantly more often than during the initial learning The most natural explanation would seem to be that the latter two culs-de-sac, lying on the same side of the pathway, are located after rotation in the general direction of approach to the old position of the food box. This shift in the locus of errors is in agreement with expectation on the supposition that the general orientation tendency of the initial learning is carried over, in some measure, to the new situation The shift is less clearly indicated in the results of Groups B, C, and D, which were smaller in size. That the tendency appears to be present to some extent throughout, even though other conditions were being varied from group to group, suggests that it may be a factor of considerable significance in normal learning situations as well.

Test 2

In this test, two patterns of a modified Y-maze, the turns in the one pattern being the reverse of those in the other, were employed These were arranged from units of the Warner-Warden maze (8), the ground plan of both patterns being shown in Figure 2 A total of 16 male white rats, weighing approximately 110 grams, were tested. They were placed singly in the entrance box for 30 seconds, then transferred to the food box and allowed to feed for 10 seconds on each of three days before beginning the training. One trial a day was given during the training proper until the norm of three successive perfect trials was reached. On the day following, they were given one trial only in the maze with turns reversed. The scores covering the learning period were as follows. average trials, $3.1 \pm 0\,9$; average total time, 10.3 ± 4.7; average time of last trial, $3\,0 \pm 0\,42$.

Exactly 50% of the animals entered the cul-de-sac on the first trial of the initial learning series. In the one trial given on the reversed pattern, only two animals entered the cul-de-sac, which shows that the general orienting tendency did not carry over under the present condition in any effective manner. It should be noted, however, that the time score showed a marked increase under the new condition, the average time being 4.7 seconds as against 3 0

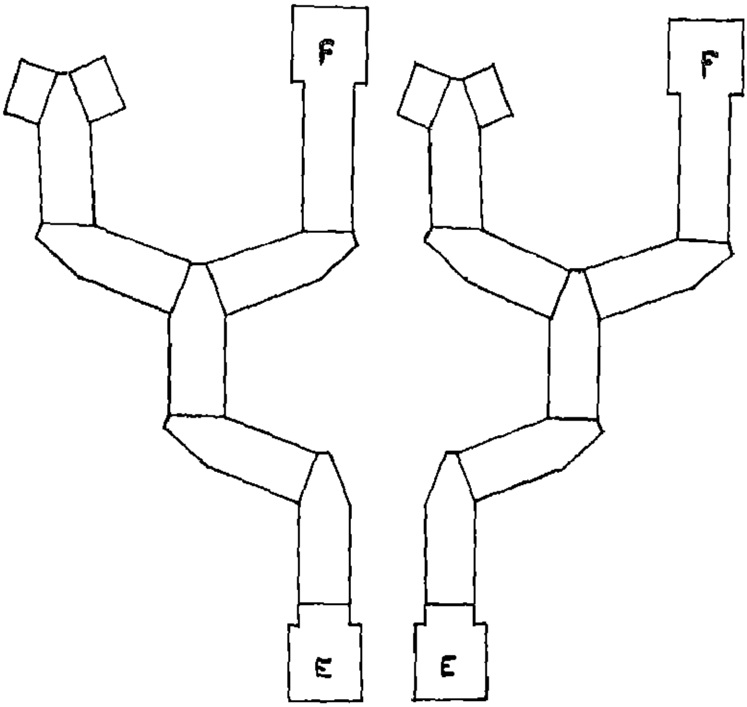

FIGURE 2
MODIFIED Y-MAZE
The original pattern is shown on the left and the reversed pattern on the right.

seconds on the last trial of the training series The time was very much longer in the case of the two rats which entered the cul-de-sac than for the other 14 animals, the score being 7 4 seconds for one and 12 0 seconds for the other, while the average score for the 14 successive animals was only 4.0 seconds.

TEST 3

The aim of this test was to determine whether or not the white rat can learn, under carefully controlled conditions, to turn consistently to the north in reaching the food box The apparatus employed was a simple T-maze, with wooden sides 5.5 inches high and a mesh top, the pathway being 5 inches wide The pathway leading to the

arms, and the arms themselves, were 15 inches long. At a point 11 inches inward from the end of each arm a partition, 2.5 inches high, was placed, which kept the food out of sight of the animal until this partition had been crawled over. Food was placed at the end of both so as to equalize the odor conditions, but the food in the south arm, or cul-de-sac, was always enclosed in a wire-mesh box so that it was not available to the animal. In order to eliminate visual cues from the environment, the table on which the maze rested was screened over with double-ply black satin so as to form a dark chamber 36 x 36 x 40 inches, this being lighted by a 25-watt frosted bulb placed centrally over the maze, near the top of the chamber. Before each daily trial, the animals were placed in a cage directly under the center of the maze table for one hour, and were carried in the same direction in being transferred from this cage to the entrance box. Two rats from Group I and two from Group II were tested. The incentive was whole-wheat bread. Observations were

TABLE 3

SHOWING RESPONSES TO GOAL REQUIRING TURN TO NORTH

R and *L*, right and left; *N* and *S*, north and south.

Trial	North position	Rat 1		Rat 2		Rat 3		Rat 4	
1	R	N	R	N	R	S	L	N	R
2	L	S	R	S	R	S	R	N	L
3	R	S	L	S	L	N	R	S	L
4	L	N	L	S	R	N	L	N	L
5	L	N	L	S	R	N	L	N	L
6	R	N	R	S	L	S	L	S	L
7	L	S	R	N	L	N	L	N	L
8	R	S	L	N	R	S	L	S	L
9	R	N	R	N	R	S	L	N	R
10	L	N	L	S	R	N	L	N	L
11	L	S	R	N	L	N	L	N	L
12	R	N	R	N	R	S	L	S	L
13	L	S	R	S	R	N	L	N	L
14	R	N	R	N	R	S	L	S	L
15	R	N	R	N	R	S	L	S	L
16	L	S	R	S	R	N	L	N	L
17	R	N	R	N	R	S	L	S	L
18	L	S	R	S	R	N	L	N	L
19	L	S	R	S	R	N	L	N	L
20	R	N	R	N	R	S	L	S	L
21	rot. 90°		R		R		L		L
22	rot. 90°		R		R		L		L

made through a small peep hole, 0.75 inches in diameter The north and south position of the food box was varied irregularly in accordance with the plan indicated in the first column of Table 3 The results covering the first 20 trials, and two later trials in which the maze was rotated 90° are also given in Table 3. The animals formed marked position habits as might have been predicted. It appeared altogether unlikely that these would be broken up without resorting to punishment. Since the application of punishment did not seem feasable at the time, the problem was discontinued.

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LE FACTEUR D'ORIENTATION GÉNÉRALE DANS L'APPRENTISSAGE DU LABYRINTHE PAR LE RAT BLANC

(Résumé)

Dans la première expérience on a étudié l'influence de la rotation et d'autres facteurs, introduits apres l'apprentissage, sur le rendement dans le labyrinthe On a trouvé que la rotation du labyrinthe seul, ou celle du labyrinthe et de la cage sur leur axe commune ont changé le lieu des erreurs dans le rendement suivant de sorte de suggérer que l'orientation générale précédente a été transferée a la situation nouvelle On n'a fait aucune analyse relative à la nature de la tendance à l'orientation La deuxième expérience a étudié l'influence du renversement d'un type spécial de labyrinthe Y sur le lieu des erreurs. Dans cette situation simple l'effet du premier labyrinthe n'a pas été transféré d'une manière définie au deuxième

La troisième expérience a compris un essai préliminaire d'entraîner le rat blanc à tourner constamment au nord mais il a fallu abandonner ceci à cause de la fixité des habitudes de position

WARDEN ET FOX

DER FAKTOR DER ALLGEMEINEN ORIENTIERUNG IN DER BEHERRSCHUNG VON LABYRINTHEN DURCH WEISSE RATTEN

(Referat)

Im Hauptversuch wurde der Einfluss der Rotation und anderer, nach dem Lernen eingeführter Faktoren auf das Benehmen im Labyrinth untersucht. Es wurde festgestellt, dass Rotation des Labyrinthes allein, oder des Labyrinthes und des Käfigs um ihre gemeine Achse, den geometrischen Pfad ('locus') der späteren Fehler auf eine Weise verschob, welche andeutete, dass die frühere allgemeine Orientierung auf die neue Lage übertragen wurde. Eine Analyse bezüglich der Natur der orientierenden Tendenz wurde nicht gemacht. Der zweite Versuch befasste sich mit dem auf den geometrischen Pfad der Fehler ausgeübten Einfluss, wenn eine besondere Sorte von Y-Labyrinth umgekehrt wurde. In dieser einfachen Situation wurde der Effect aus dem ersten Labyrinth nicht auf sehr bestimmte Weise in das zweite übertragen. Der dritte Versuch umfasste einen vorbereitenden Versuch, weisse Ratten so zu dressieren, dass sie sich beständig dem Norden zuwendeten. Dieser Versuch musste aber wegen der Festigkeit von Stellungsgewohnheiten ('position habits') aufgegeben werden.

WARDEN UND FOX

CAN CONDITIONED RESPONSES BE ESTABLISHED IN THE NEWBORN INFANT?*[1]

From the Psychological Laboratories of the Ohio State University

DOROTHY POSTLE MARQUIS

THE PROBLEM

The present problem was undertaken to investigate the contention made by the Pavlovian school of Russian psychologists and physiologists that the formation of conditioned responses in newborn infants is impossible because the cerebral cortex of the human infant functions only very incompletely the first few months after birth.

Most neurologists agree that the cerebral cortex of the newborn infant functions very imperfectly, if at all. Various investigators (Pavlov, Krasnogorski, Bechterew, and Lang and Olmsted) have failed to establish conditioned responses in infants under five months of age and in decerebrate animals, and have attributed their failure to the incomplete functioning of the cortex of their subjects. Pavlov (8) asserts that no new nervous connections can be formed except in the cerebral hemispheres.

One very important issue, however, seems to have been overlooked by these investigators. It is evident that when the cerebral cortex has reached functional maturity, it is the "dominant part" or the "pace setter" of the central nervous system (Child, 3). On the other hand, is it not logical to assume that before the cortex has reached its full development, the lower centers (thalamus, mid-brain, medulla, etc.) serve even more important functions than they do at a later time when the inhibitory action of the cortex dominates them? It is a well-established neurological fact that in the human infant at birth, the midbrain, which in the adult is a highly important correlation center for the reflexes of sight, hearing, and touch, is completely myelinated and apparently fully functional. Tracts to and

*Recommended by Albert P. Weiss and received for publication by Carl Murchison of the Editorial Board, August 25, 1930.

[1]The present paper is a brief summary of a dissertation for the doctor's degree, "Habit Formation in the Newborn Infant," a detailed account of which is available at the Graduate School of Ohio State University. The experiment was performed under the direction of Dr. A. P. Weiss.

from the red nucleus of the midbrain are also completely developed at birth. In the medulla oblongata there are present at birth important relay centers which regulate sucking, respiration, digestion, and secretion. Moreover, the thalamus, which in adults acts as a relatively complex correlation center for all impulses coming into the cortex, has at the time of birth reached a fairly high degree of functional maturity. Can we assume that the cortex possesses some mysterious function or power qualitatively different from any other part of the nervous system, so that it is only by means of *its* function that a response to one stimulus is replaced by a surrogate response? This seems improbable, since it is largely in the *amount* of its correlating tissue that the cortex differs from the other parts of the nervous system

If the last conclusion is sound, then it should be possible to set up conditioned responses in the newborn human infant by means of the subcortical correlation centers, whose functions are the more complete before the inhibitory influence of the cortex has developed, *provided* we select reactions which are relatively well integrated at this stage of biological development. For our experimental work, in accordance with the principles above, as the unconditioned response the feeding reactions of the infant (sucking, mouth-opening, and quieting, etc.) to a food stimulus (milk from the nursing bottle) were chosen. The conditioned stimulus was the sound of a buzzer. In these stimuli there are represented an auditory and a tactual-and-gustatory stimulus, and probably secretory and kinaesthetic stimuli, all of whose impulses possess subcortical correlation centers The specific experimental problem was to ascertain whether, after a sufficient number of pairings of buzzer and bottle, the buzzer alone would lead to feeding reactions.

Method

Ten subjects were used in this experiment, all newborn children of clinical maternity patients at the Ohio State University Hospital. Three Negro infants were used, two girls and one boy, and seven white infants, four girls, and three boys. The plan of the experiment was never to permit the infants, from the first time they were fed, to feed without the bottle being immediately preceded or accompanied by the sound of the buzzer. The infants are fed six times each day Instead of being taken to the mothers for nursing, the subjects of this experiment were brought one at a time into the ex-

perimental room and were fed from the bottle, milk which had been pumped from their own mothers' breasts The period of experimentation extended from the first time the infants were fed (24 hours after birth) to the tenth day of life.

The specific experimental procedure after the infants were brought into the experimental room was as follows.

1 The infant was placed on a stabilimeter[2] in a small compartment, the temperature and lighting of which were kept fairly constant, and remained there with no experimental stimulation for a period varying from one to five minutes (control period).

2. At the end of this time the experimenter stepped inside the curtain of the compartment, carefully noted and recorded the infant's reactions for a few seconds, then rang the buzzer for five seconds.

3 As soon as possible after the end of the buzzer, the bottle was inserted in the infant's mouth and the buzzer rung for five seconds more after the infant started sucking

4 At various times while the infant was sucking, the buzzer was sounded for periods of five seconds

5 During each experimental period the bottle was removed from the infant's mouth from two to five times, to prevent too quick consumption of milk Each time the bottle was replaced in the infant's mouth, it was preceded by the buzzer in the manner described above

Record of the infant's reactions during the experiment was kept in *two ways—through the experimenter's recorded observations, and* through the polygraph record. The polygraph record furnished (*a*) a continuous record of the infant's movements by means of registration of the stabilimeter movements; (*b*) a record of sucking movements by means of pneumatic recording through a balloon-type capsule fastened under the infant's chin and a Marey tambour; (*c*) a time record including time of stimulation and other events during the experiment, and (*d*) the protocols of the infant's reactions during the control period. The experimenter's protocols included a detailed record of the specific reactions made by the infant for a few seconds before each buzzer, and the reactions after the buzzer began to sound, as well as the reactions at other times during the experimental period

Two experiments served as control for the results The first was a test in the control periods of the last day or last two days of each infant's experiment to see whether other stimuli would elicit re-

[2]For details of the experimental cabinet refer to (10)

actions similar to those after the buzzer. As a visual stimulus, a flashlight was projected into the infant's eyes As an auditory stimulus, a fall hammer striking the end of a tin can was used. As a second control experiment, four subjects of the same age as the experimental group were stimulated by the buzzer at feeding times without being permitted to feed immediately afterwards The latter experiment was carried out throughout a nine-day period for each infant.

Results

General The following are the results of this experiment for eight infants. The results of the first two subjects of the experiment are omitted since the method of recording was not uniform with that of the others Their reactions, in general, however, are not essentially different from those of other infants.

1 Seven of the eight infants, after a period of three to six days, began to show significant changes of reaction following the buzzer. Certain reactions began to increase, others to decrease

2 The reactions following the buzzer on the first few days with all infants were predominantly an increase in general activity or crying, no change in general activity or crying, or an occasional decrease of general activity

3. The reactions following the buzzer which increased were sucking, mouth-opening, and cessation of general activity and crying. All of these reactions are directly related to foodtaking.

4. The reactions following the buzzer which decreased were general activity and crying—reactions which are not usually concomitants of the foodtaking response.

5. Reactions preceding the buzzer showed few significant changes throughout the experiment. In four instances mouth-opening preceding the buzzer increased on the seventh and eighth days of the experiments. This was interpreted as a possible indication that the whole experimental situation might be taking on the properties of conditioned stimuli.

6. Sucking without an object in the mouth very rarely occurred before the buzzer sounded.

7. The infants showed great individual differences in the onset of the change of reaction after the buzzer, in the degree of the change, and in the suddenness with which the change occurred.

8 Increase in mouth-opening and decrease in crying after the

buzzer, in most infants, started on the fourth day, while increase in sucking and general activity began, in most instances, on the fifth day

9 With one exception, the seven infants who showed an increased number of foodtaking reactions *after* the buzzer, showed least increase when they were quiet and asleep *before* the buzzer sounded.

10. One infant failed to show increase in foodtaking reactions following the buzzer. This infant's physiological condition was poor, he never seemed hungry, and was not as responsive generally to stimuli as the other infants. This infant, all through the experiment, showed either no significant change of activity when the buzzer sounded, or increase in general activity and crying.

11. In the first control experiment where the infants were stimulated during the control periods on the last or the last two days of the experiment by the flashlight and by the hammer striking the can, they never responded by any foodtaking reactions. Usually there was no change in general activity and crying or there was increased general activity and crying.

12. In the second control experiment, in which four additional infants were stimulated by the buzzer at feeding times without ever feeding immediately afterward, the infants in the majority of cases showed increase in general activity and crying after the buzzer throughout the nine-day period.

Results of Individual Infants

1 *Infant Rn* (*white, female*) Infant Rn was the "brightest" of all the subjects She was unusually alert to all stimuli and reached the highest percentage in number of feeding reactions after the buzzer The changes in her reactions after the buzzer were as follows: *Sucking* reactions increased from zero on the first two days to an average of 74% frequency[3] on the seventh, eighth, and ninth days *Mouth-opening* increased from zero on the first day to 75% on the last day. *Cessation of crying* increased from zero on the first two days to 100% on the sixth, seventh, eighth, and ninth days; and *cessation of general bodily activity* from zero on the first four days to 100% on the seventh and eighth days *General activity* after the buzzer decreased from 92% on the first day to zero on the last day, and *crying* from 46% on the first day to zero on the last four days Instances when Rn remained *quiet and awake* after the buzzer

[3]As compared with frequency of the buzzer stimulations.

decreased from an average of 26% on the first two days to zero on the last two days. There were no significant differences in the number of conditioned responses, whether the infant was quiet and awake, quiet and asleep, or active and awake before the buzzer sounded. In the control experiment she never responded to the light or sound by any feeding reaction

2. *Infant Cb* (*white, female*) The change in the Cb infant's reactions to the buzzer proceeded in the following manner *Sucking* increased from zero on the first four days to an average of 42% on the last two days *Mouth-opening* after the buzzer showed a significant predominance over mouth-opening before the buzzer from the second day, and a predominance over mouth-closing after the buzzer from the fourth day on. *Cessation of crying* increased from zero on the first three days to 100% on the sixth, seventh, and eighth days. *Cessation or significant decrease of general activity* showed an increase from zero on the first three days to 100% on the last two days *General activity* after the buzzer decreased from 62% on the first day to zero on the last two days, and crying from an average of 17% on the first three days to zero on the last three days General activity and crying before the buzzer remained about the same throughout the experiment. When the infant was quiet and asleep before the buzzer, she seldom made "feeding responses" to the buzzer.

3. *Infant Cla* (*white, female*). Foodtaking responses at the sound of the buzzer began in the Cla infant on the fourth day, after approximately 140 to 150 pairings of buzzer and bottle. *Sucking* after the buzzer increased from zero on the first four days to an average of 30% on the last three days. *Mouth-opening* increased from zero on the first day to 62% on the last day. *Cessation of general bodily activity* increased from zero on the first day to 100% on the last day; and *crying*, from zero on the first day to 100% from the fourth day on. *General bodily activity* decreased from 67% on the first day to zero on the last day, and *crying* from 17% on the first day to zero on the last five days. General activity before the buzzer showed no significant change throughout the experiment. Crying before the buzzer varied, but showed no consistent tendency to increase or decrease in the course of the experiment. Fewer "feeding reactions" after the buzzer occurred when the infant was quiet and asleep before the buzzer sounded. No feeding reactions occurred to the stimuli in the control experiment

4. *Infant Car* (*Negro, female*). Change of reaction following

the buzzer began with the Car infant on the fourth day of the experiment after 125 to 130 pairings of buzzer and bottle. *Sucking increased from zero on first day to 53% on the last day. Mouth-opening* increased from 20% on the first day to 35% on the sixth day, then decreased as sucking increased. *Cessation of crying* increased from an average of 17% on the second and third days to an average of 95% on the last two days, *cessation of general activity* from zero on the first four days to 100% on the last two days. Crying before the buzzer increased from zero on the first day to 53% on the last day, while general bodily activity before the buzzer increased from zero on the first day to 47% on the last day The infant showed more feeding reactions after the buzzer when she was active and awake than when she was quiet and awake or quiet and asleep. No feeding reactions occurred to the control stimuli on the last two days of the experiment

5 *Infant Mar (Negro, female).* The change in the reactions to the buzzer was less pronounced in the Mar infant than in most others. The increase in reactions after the buzzer was as follows: *Sucking* increased from zero on the first four days to 41%, 24%, and 23%, respectively, on the seventh, eighth, and ninth days; *cessation of general activity* from zero on the first two days to an average of 56% on the last two days. *Mouth-opening* after the buzzer showed an increase over mouth-opening before the buzzer from the fifth day, with one exception on the seventh day. *General activity* after the buzzer showed a slight decrease from an average of 26% on the first three days to 19% for the last three days, while general activity before the buzzer increased on the last three days *Crying* after the buzzer decreased from 17% on the first day to zero on the last three days The instances when the infant remained quiet and awake after the buzzer decreased significantly from the fifth day. Highest frequency of feeding reactions after the buzzer occurred when the infant was active and awake before the buzzer. No feeding reactions occurred to the control stimuli on the last day of the experiment.

6. *Infant Lld (Negro, male)* With the Lld infant the change of reactions following the buzzer occurred in the following fashion: *Sucking* increased irregularly from zero on the first three days to 32% on the fourth day, 73% on the sixth day, and an average of 40% on the last three days *Mouth-opening* increased irregularly from 11% on the first day to 46% on the last day. *Cessation of general activity* increased from zero on the first two days to 50% on

the third and fourth days and 100% on the next three days. On the last two days it decreased to an average of 76%. General activity before the buzzer increased from an average of 35% on the first three days to 63% on the last three days, while general activity after the buzzer showed a corresponding decrease from 34% to 14%. *Crying* before the buzzer remained about the same throughout the experiment, crying after the buzzer decreased from 22% on the first day to zero on the second day, never increasing to more than 6% on any day thereafter. The percentage of feeding reactions after the buzzer was highest when the infant was active and awake before the buzzer In the control experiment the Lld infant responded three times (once to the light and once to the sound) in 24 stimulations, by slight quieting of general activity and crying.

7. *Infant Mont* (*white, male*). The changes in the Mont infant's responses to the buzzer occurred in the following manner Sucking never attained a very high percentage of frequency However, it increased from zero on the first two days to 6% on the third day, and 33% on the seventh and ninth days *Mouth-opening* after the buzzer was less than mouth-opening before the buzzer on the first day, equal to it on the second day, and exceeded it from the third day on. A very great increase in mouth-opening after the buzzer occurred on the fourth day when the percentage rose from 6% on the third day to 65% on the fourth. *Crying* after the buzzer exceeded crying before the buzzer on the second day On the third day cessation of crying reached 100%, and in almost every case after this crying stopped as soon as the buzzer sounded. *Cessation of general activity* after the buzzer showed a steady increase from 12% on the first day to 100% on the sixth day and 89%, 90%, and 82%, respectively, on the last three days. Although general activity before the buzzer showed no significant change throughout the experiment, general activity after the buzzer decreased from an average of 67% on the first two days to an average of 14% on the last two days. There was little difference in the percentage of feeding reactions after the buzzer whether the infant before the buzzer was quiet, active, or asleep In the control experiment, the infant reacted to the sound twice out of 24 stimulations by cessation of crying.

8. *Infant Zim* (*white, male*). The Zim infant was an infant whose physiological condition was very poor. He showed no conditioned reactions to the buzzer. *General activity and crying* after the buzzer exceeded general activity and crying before the buzzer

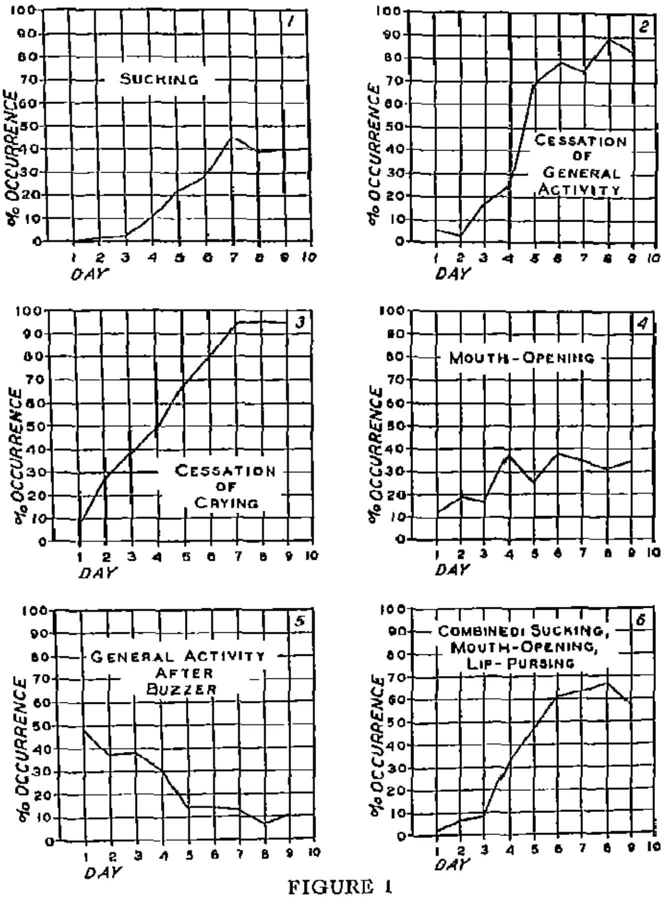

FIGURE 1

REACTIONS AFTER BUZZER

Composite curves of seven infants (Zim excluded). Percentage of the different conditioning indices

Sucking is differentiated from mouth-opening and closing by including more lip-pursing and more tongue movement

Cessation of general activity means a sudden cessation of kicking, squirming, etc., as soon as the buzzer sounds

Cessation of crying means sudden stopping of crying at the sound of the buzzer

Mouth-Opening (4) *and Combined: Sucking, Mouth Opening, and Lip-Pursing* (5) include only those respective mouth-movement components which were not occurring before the buzzer sounded. Sucking, mouth-opening, and lip-pursing combined includes the percentage of times when one or any combination of these occurred at the sound of the buzzer

Percentage Occurrence is derived by dividing the number of times each specific reaction occurred at the sound of the buzzer by the number of pairings of bottle and buzzer on each day

throughout the experiment. In only one instance did *sucking* ever occur after the buzzer. *Mouth-opening* after the buzzer slightly exceeded mouth-opening before the buzzer after the third day, but its highest frequency was only 20%, on the seventh day.

The curves of Figure 1 present graphically the composite results of the seven infants who showed conditioned foodtaking response to the buzzer.

Since the combined averages of all infants, such as those shown in Figure 1, obscure individual differences, the following graphs of the results of Infants Rn and Mar are presented to show an instance of a high percentage of conditioning and an instance of a much lower percentage of conditioning.

Results of Second Control Experiment

In the second control experiment, in which four infants were stimulated by the buzzer at feeding times without ever being permitted to feed immediately afterward, practically no "feeding reactions" ever occurred after the buzzer. Their occurrence after the buzzer was not more frequent than their occurrence before the buzzer. For every infant the most frequent reactions to the buzzer were increased general activity and increased head-movement. No significant change in the infants' reactions after the buzzer was evident on any day of the experiment. The results of this check experiment were therefore negative

Conclusions

1. A conditioned response of foodtaking reactions to the sound of a buzzer was established in seven out of eight newborn infants during the first ten days of life.

2. Since present neurological evidence indicates that the cerebral cortex of the newborn infant functions only very incompletely the first few months after birth, we may infer that *conditioned responses can be formed in newborn infants, at least, by subcortical correlation* The type of responses included in the conditioned foodtaking reactions to the buzzer indicates that the midbrain and especially the red nucleus was important as a controlling mechanism

3. The foodtaking response in the newborn infant includes a wide variety of reactions.

4. The results of this experiment bear out, in general, Pavlov's contention that an alert state of the subject is favorable to the forma-

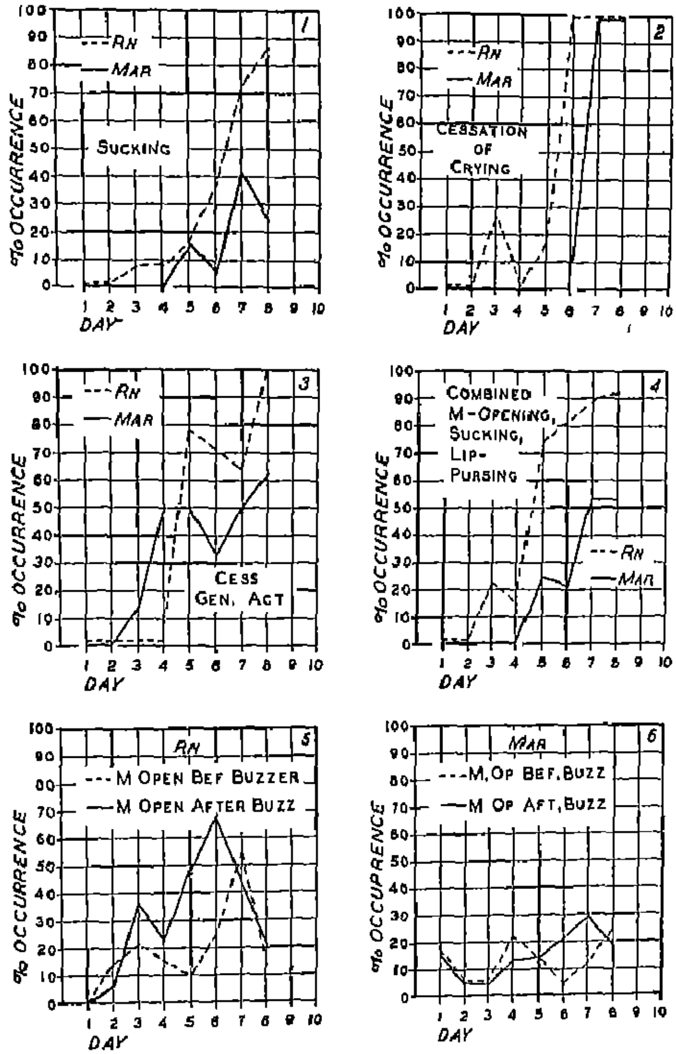

FIGURE 2

Reactions After Buzzer of Infants Rn and Mar

A comparison of an instance of high percentage and one of low percentage of conditioning

tion of conditioned responses, since in most cases a higher frequency of feeding reactions after the buzzer occurred when the infants were active and awake.

5. The contention that a good physiological condition of the subject is necessary to the development of conditioned responses finds support in the case of the Zim infant, who showed no conditioning to the buzzer.

6. Individual differences in learning ability are present even at this early age.

7. Systematic training of human infants along social and hygienic lines can be started at birth.

8. Since habit formation may begin so early, the sharp lines drawn by some writers in their classifications of some acts as instinctive and some acts as learned must be viewed with some hesitation.

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PEUT-ON ÉTABLIR DES RÉPONSES CONDITIONNELLES CHEZ LES NOUVEAUX-NÉS?

(Résumé)

Cet article a été écrit dans le but de réfuter l'assertion de l'École Pavlov de psychologues et de physiologists russes que la formation des réponses conditionnelles chez les nouveaux-nés humains est impossible, parce que l'écorce cérébrale de l'enfant nouveau-né ne fonctionne que d'une manière très incomplete pendant les premiers mois après la naissance

Les sujets de l'expérience ont été dix nouveaux-nés à l'Hôpital de l'Université de l'Etat d'Ohio Depuis le deuxième jour jusqu'au dixième jour de la vie, on ne leur a jamais permis la bouteille sans qu'elle ne soit immédiatement précédée ou accompagnee du son d'une sonnette électrique

En commençant le troisième jour, le quatrième ou le cinquième, neuf des sujets ont commencé à répondre à la sonnette avec des "reactions de manger" avant que la bouteille ait été mise à la bouche Les "réactions de manger" ont compris l'action de sucer, de garder la bouche ouverte, et la cessation soudaine de l'activité générale du corps et des larmes Un sujet seulement a manqué de montrer des réactions de manger à la sonnette au cours de l'expérience, et celui-ci a été un enfant dont la condition physiologique a été on ne peut plus faible.

Les réactions conditionnelles de prendre de la nourriture ont été relativement spécifiques au son de la sonnette, puisqu'on n'a pu les causer par des stimuli visuels ou par d'autres stimuli auditifs administrés le neuvième jour ou le dixième jour de l'expérience

Comme expérience de contrôle, quatre sujets du même âge que le groupe expérimental ont été stimulés par la sonnette à l'heure de manger sans être permis de manger immédiatement après Chez ces sujets les "réactions de manger" ne sont jamais montrees comme réponses à la sonnette pendant l'expérimentation de neuf jours

Ces résultats indiquent qu'on peut établir des réponses conditionnelles chez les nouveaux-nés, et que le mécanisme probable de leur formation se trouve dans la corrélation sous-corticale.

Outre les données trouvées expérimentalement, l'article résume brièvement la significance psychologique de la formation de bonne heure des habitudes chez les enfants humains.

MARQUIS

KÖNNEN BEI NEUGEBORENEN KINDERN BEDINGTE ERWIDERUNGEN GEGRÜNDET WERDEN?

(Referat)

Man unternimmt hier die Widerlegung der Behauptung der Pavlovschen Schule der Russischen Psychologie, die Grundung bedingter Erwiderungen bei neugeborenen Menschenkinder sei deshalb unmoglich, weil die Gehirnrinde des Kleinkindes wahrend der ersten Paar Monate nach der Geburt nur sehr unvollstandig tatig sei.

Als Versuchspersonen dienten zehn neugeborene Kinder von Patientinnen im Krankenhause der Staatsuniversitat von Ohio. Von zweiten bis zum zehnten Lebenstage wurde es den Kindern nur dann erlaubt, Nahrung einzunehmen, wenn die Flasche von dem Schall einer Drohnklingel ("buzzer") unmittelbar angekundet wurde oder mit ihm einherging.

Am dritten, vierten, oder funften Tage fingen neun der Versuchspersonen an, auf die Klingel mit Essbewegungen zu erwidern, ehe ihnen die Flasche in den Mund gesteckt wurde Die "Essbewegungen" umfassten das Saugen, das Aufhalten des Mundes, und das plotzliche Aufhoren der allgemeinen korperlichen Bewegungen und des Weinens Nur eine einzige Versuchsperson zeigte im Laufe des Versuches keine Essbewegungen als Erwiderung auf die Klingel, und jene war ein Kind dessen korperlicher Zustand äusserst kummerlich war. Die bedingten Esserwiderungen waren relativ spezifisch auf den Schall der Klingel gerichtet, da es nicht möglich war, sie durch visuelle oder andere auditive Reize hervorzurufe, welche am neunten oder am zehnten Tage des Versuches dargeboten wurden

In einem Kontrollversuch wurden vier Versuchspersonen im selben Alter wie die erste Versuchsgruppe mit der Klingel in der Essstunde gereizt, indem man sie nie gleich nachher essen liess. Bei diesen Versuchspersonen zeigte sich im Laufe der neun Tage des Versuches nie Essreaktionen als Erwiderungen auf die Klingel.

Diese Ergebnisse deuten an, dass bedingte Erwiderungen bei neugeborenen Kindern gegrundet werden konnen, und dass der Mechanismus der Bildung dieser Erwiderungen wahrscheinlich in subkortikalen Verhaltnissen liegt.

Die Abhandlung bietet nicht nur die Versuchsergebnisse dar, sondern skizziert auch kurz die psychologische Bedeutung der sehr fruhen Gewohnheitsbildung bei Menschenkindern

MARQUIS

SHORT ARTICLES AND NOTES

STUDIES ON CUTANEOUS LOCALIZATION III THE AGE OF ONSET OF OCULAR DOMINANCE

SAMUEL RENSHAW AND ROBERT J WHERRY

THE PROBLEM

In two previous papers (5, 6) the problem of differences between children and adults in the accuracy of locating punctiform stimulations upon the skin was raised Seeing children showed errors of distinctive less magnitudes than adults. The differences in the relative sizes of the errors could not be attributed to boundary conditions, that is, if the errors were scaled proportionately to the relative size of the hands (the distal-proximal and radial-ulnar meridians), the same proportional superiority for the children over the adults remained. Since theoretical significance has been attached to such differences, it was decided to explore more carefully the conditions under which such differences occur In the differentiating experiments, children were then compared with adults, using both a tactual-kinaesthetic method and a visual method in which the localizing movement was reduced to a minimum and the localizations were made upon a printed map of the stimulated area Next, a group of congenitally blind children and adults were compared, using the tactual-kinaesthetic method. A comparison of results of these experiments enabled us to derive the principle that the alleged superiority of children over adults was due to a shift in the dominance of one receptor field over the other An examination of the data led us to assume that the transformation should be found to take place somewhere near the age of puberty The present experiment was made in order to determine the trustworthiness of this assumption

Boring (1) has argued that there is a constant relationship between the limen for two points and the magnitude of the error of localization. If Boring's logic is sound, then we can use his generalization in still another

way We can advance the argument that what conclusions have been drawn with respect to the space limen for two points should also be expected to hold for the errors of localization.

Rivers and MacDougall (quoted in 4) have advanced the "law" that sensory discrimination exists in inverse proportion to the ages and to status of the civilization of a population. Comparing the average limens for two points on the forearm, 50 Murray Island men gave a mean of 19 8 mm., and 25 Murray Island boys a mean of 14 mm Dyak men gave a forearm limen of 35 mm Toda men gave a mean of 40 5 mm., and Toda boys were found to have a mean of 30 mm. English working men gave a mean of 44.6 mm., and Oxford preparatory school boys, 38 9 mm., Oxford elementary school boys, 36 2 mm , and Cambridge graduates and undergraduates, 51.5 mm. These are the figures from which the generalization was drawn.

We hold that the Rivers-MacDougall "law" is based upon a fallacy, namely, that of comparing the *best* sense mode of one group or age with the *poorest* functional mode of the other group When the data are rendered comparable, as has been shown in the two previous papers (5, 6), the differences disappear The present paper presents further evidence confirmatory to this point.

Methods and Results

Fifty-five male subjects were used in this experiment, five in each age group from the sixth to the sixteenth year, inclusive. Table 1 presents the means and standard deviations of the means of 50 localizations by each *S*, using the tactual-kinaesthetic method, and 50 localizations using the visual method Thus, the accompanying data represents the means of 250 localizations by five subjects at each age, using each of the two methods The following things seem evident from examination of Table 1

1. Tactual-kinaesthetic localization is superior to visual from the eighth to the twelfth year, at which time there is no difference.
2. At puberty there is an abrupt change (increase in accuracy in both methods).
3 Between the thirteenth and fourteenth years there is an inversion in the relative accuracy of localization by the two methods, and the visual becomes dominant.
4 Visual localization is distinctly superior thereafter in the fourteenth, fifteenth, and sixteenth years The divergence continues to increase and reaches its maximum in adulthood.

To anticipate the objection that the differences in the sizes of the mean error are to be accounted for by boundary conditions, that is, to the distribution-density of receptors in hands and arms differing in size as much as those of eight-year-old children and adults, attention need only be called to the following facts

TABLE 1

AGE DIFFERENCES IN MEAN ERRORS OF LOCALIZATION ON THE SKIN

Method	Subject number	Age 6	7	8	9	10	11	12	13	14	15	16	Adult
Tactual-kinaesthetic	1	10.35	10.30	8.80	7.70	8.65	6.85	6.85	10.80	8.00	7.85	6.70	11.90
	2	8.05	9.00	7.80	7.80	6.90	12.50	9.70	7.20	6.35	9.45	9.00	10.10
	3	10.05	9.50	6.85	10.15	8.05	5.95	7.25	10.65	6.55	9.95	7.15	9.20
	4	13.35	8.60	6.40	8.55	7.00	10.80	12.50	11.50	7.05	7.65	8.65	12.40
	5	7.15	8.30	6.50	7.85	10.50	7.35	8.65	4.85	9.35	8.65	6.20	7.95
	Group mean	9.75	9.16	7.35	8.41	8.24	8.68	8.98	9.00	7.30	8.71	7.64	10.31
	SD Mean	499	394	397	390	426	452	472	499	403	318	398	490
Visual	1	9.60	9.65	8.35	7.05	11.00	10.30	10.90	5.70	8.15	7.95	5.05	6.10
	2	10.50	7.40	8.50	10.85	11.15	6.05	8.05	6.55	5.50	8.45	5.40	5.35
	3	8.40	6.25	8.45	7.85	11.00	9.05	11.15	14.15	9.55	4.30	4.50	5.50
	4	9.70	10.50	9.65	12.00	8.70	10.75	8.90	13.05	4.85	6.10	7.65	6.10
	5	5.85	9.05	10.60	12.05	6.30	10.70	6.65	9.10	5.65	9.50	5.20	7.10
	Group mean	8.71	8.71	9.00	9.99	9.56	9.23	8.93	9.71	6.64	7.26	6.66	6.04
	SD Mean	511	410	.464	.477	499	551	510	471	355	416	356	383

1. Congenitally blind adults with much larger hands and arms localize with the approximate mean error of the seeing children

2. The executant movement in localizing is susceptible to practice effect in large degree

3. There is no known neurological or psychological evidence to support the notion that accuracy of localization is to be accounted for by the hypothetical distribution of receptors in the skin and fascia The work of Dallenbach (3) and the fact that the feltwork of subcutaneous nerve-fibres is all-pervasive in the tissues makes the question of density of receptors per unit area an extremely doubtful ground for any such conclusion

4. The studies of Cole (2) show that regions which have, so far as is known, equal or nearly equal density of fibres in the superficial tissues, have widely differing mean errors of localization. In view of the foregoing points, it is extremely unlikely that age-differences are due to boundary conditions No reliable measurements of the mean palmar distal-proximal meridian of the hands of children at various ages could be found in the anthropometric tables. Calculations were made based on the assumptions of a 3 to 1 difference in the sizes of adult and child surface areas This correction also failed to account for the measured difference of the errors.

When seeing children utilize their less effective method (visual) and seeing adults utilize their poorest method (*T-K*), no true difference in the accuracy of localization was found, nor was there a true difference where the best methods of the two groups were compared (5, 6). This answers the question of the alleged superiority of children over adults. It is the fallacy in the alleged Rivers-MacDougall "law." The widespread theoretical deductions drawn from such evidence are held to be erroneous and unjustified.

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ALEŠ HRDLIČKA *Children Who Run on All Fours and Other Animal-Like Behavior in the Human Child.* New York McGraw-Hill, 1931. Pp. 418

Doctor Hrdlička has made a valuable contribution to the scant knowledge of what he rightly calls "a most promising and fascinating field of research,"—the development of locomotion in the human young The book is divided into two parts The first part (95 pages) is the author's tabulation and analysis of the data given in the second part. The latter (page 97 to page 403) gives the individual reports, in letters quoted verbatim, as the author received them

There are reports of 369 individals of the white race and 18 of other races The discussion and conclusions of the author are based upon 331 cases of whites reported in more detail He discusses "The Performance of Running on All Fours," "Mentality of Children Who Run on All Fours," "Other Animal-like Manifestations," "Curious Initial Postures and Odd Modes of Locomotion," and "Causes of Animal-like Manifestations in the Human Child" All of these topics are presented in clear and simple language. In summarizing the author states that·

"These manifestations . . . . occur predominantly in physically and mentally healthy, strong, and even exceptional children"

"The habit of walking on all fours is more frequent in boys than in girls"

"The children manifesting the habit, with infrequent exceptions are marked by low morbidity and very low mortality."

"These phenomena constitute substantial further evidence of our derivation from forms prehuman"

"As before birth . . so the child after birth recapitulates and uses for a time various phases of its prehuman ancestral behavior"

The last two statements indicate Doctor Hrdlička's primary interest. The point of view of the entire discussion of the phenomena under consideration is obviously that of an anthropologist. That he is a scholar in that sphere of scientific research is apparent, but at the same time one

feels that his knowledge of the signposts of simian ancestry may not necessarily include a knowledge of the psychology of the human infant

Questions the psychologist is sure to ask concern the selection of the group and the reliability of the data

The very manner of obtaining the data suggests a selected group Following the publication of an article in 1927 by Dr. Hrdlička a world-wide request through the *Literary Digest*, *Science News*, *Science*, and newspapers resulted in his receiving the letters which constitute the data of this volume In reading the letters, it was impossible for the reviewer to avoid the impression that the writers had received a suggestion that walking on all fours, i e, on hands and feet, indicated a general superiority and, hence, were eager to report some member of the family as having used this mode of progression. Knowing how sensational newspaper reports can be of a purely scientific article, the reviewer was interested to learn just what had been the nature of the request. Efforts to locate the request were futile Whether or not it contained such a suggestion, it would be a rare exception that parents would voluntarily report the behavior of one of their own whom they thought to be inferior Hence, it is not known that all of any population (used in the biological sense) manifesting the phenomena under consideration are reported, but only that the ones who are reported manifest the phenomena. Neither is there a control group for comparative purposes of children who did not use this particular mode of progression.

Those furnishing the data were asked to fill out a questionnaire. Experience has shown that in most cases only educated or superior people adequately fill out questionnaires Many of the letters were signed by professional people and others mention that both parents are college graduates: other indications of a selected group Superior parents do not always have superior children, yet the percentage of superiority in children of that group is higher than for the population at large

The age of the subjects reported on at the time the letters were written was nine months to eighty-four years In approximately 12 per cent of the cases the age could not be determined Of the remaining cases, about 15 per cent were fifteen years or more of age For some of these, pictures taken at the time they were walking on hands and feet bear evidence of that mode of progression However, for many of the points under discussion we are confronted with the serious factor of imperfect memory Dr. Hrdlička recognizes this in his effort to trace the inheritance of the phenomenon, but ignores it elsewhere Knowing the difficulty of analysis of movement, even under direct observation by a trained person, of a child progressing rapidly on hands and knees, the reviewer is convinced that not only are we confronted with imperfections of memory but also with inaccuracies of observation. Notwithstanding the imperfections of the data thus supplied, the letters are full of interest for any student of human behavior

Dr. Hrdlička seems to accept too readily the statements of parents regarding the mental level of their offspring. A psychologist conversant with clinical problems knows how frequently such prejudiced observers fail to recognize dullness. In a small percentage of cases, if the facts cited are correct, one would suspect retardation. In a similarly small percentage of cases there is objective proof of superiority. The most convincing argument of mental superiority is the recital of the motor accomplishments and age at walking of these children. Although Dr. Hrdlička states that "the most common effect of the all fours method of progression appears to be . . . a delay in walking erect," an analysis of the data given does not show this. The average age of walking for this group is indicated to be thirteen months. This is somewhat earlier than the average age for walking as found in scientific studies of unselected groups, and, if correct, is an indication of a superior group.

To question the validity of much of the data does not prevent one from appreciating the good qualities of the work.

One of the praiseworthy qualities is the preciseness and consistency in the use of terms. Throughout Dr. Hrdlička's discussion he uses walking on all fours to mean but one thing, namely, progressing on hands and feet. There is no confusion of terms. This is not true of some of the studies quoted in Dr. Hrdlička's historical account which renders them less valuable and makes any statistical treatment from them meaningless.

The book is abundantly provided with pictures of children in the all-fours position. These establish beyond doubt that the "bear-method" of progressing was used by these children.

Statements in the letters which were most interesting to the reviewer had to do with the modes of progression antedating "bear walking." Many state some previous method of locomotion. Many more state there was no previous progression, and others do not mention it. A few mention a series—flat on the stomach, then creeping on hands and knees, this, in turn, succeeded by creeping or "walking" on hands and feet. These last mentioned observations are in accord with data recorded by means of motion pictures of children at successive ages in a study of the development of locomotion published by the reviewer in 1927 (*Genetic Psychology Monographs*, Vol. 2, No. 5). The data obtained in that study, however, would throw doubt on the statement that any child who had not been prevented by prolonged illness or artificial means would employ creeping on hands and feet as its first mode of progression. That manner of progression requires a strength and neuro-muscular coordination which is not suddenly acquired. Report to the contrary seems likely to be due to faulty or incomplete observation.

Perhaps the greatest value in the book to the scientist is its challenge and stimulation to experimental work on the study of locomotion. To the parent desirous of cooperating with the scientist pioneering in a study of

human behavior is its suggestion for more accurately kept records. Only by directed cooperation between the two can the study of infant behavior and development advance satisfactorily.

LENOIR BURNSIDE

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Laboratory Facilities and Research. The University calls attention to its psychological laboratories, which are distinguished for range and selection of apparatus and for generosity of space. Beginning in the fall of 1931, the excellent biological laboratories are reorganized for graduate research in general physiology under the direction of Dr. Hudson Hoagland. Students working for a Doctor's degree in psychology will be expected to minor in general physiology and should equip themselves with the necessary elementary biology, physics, chemistry, and mathematics.

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